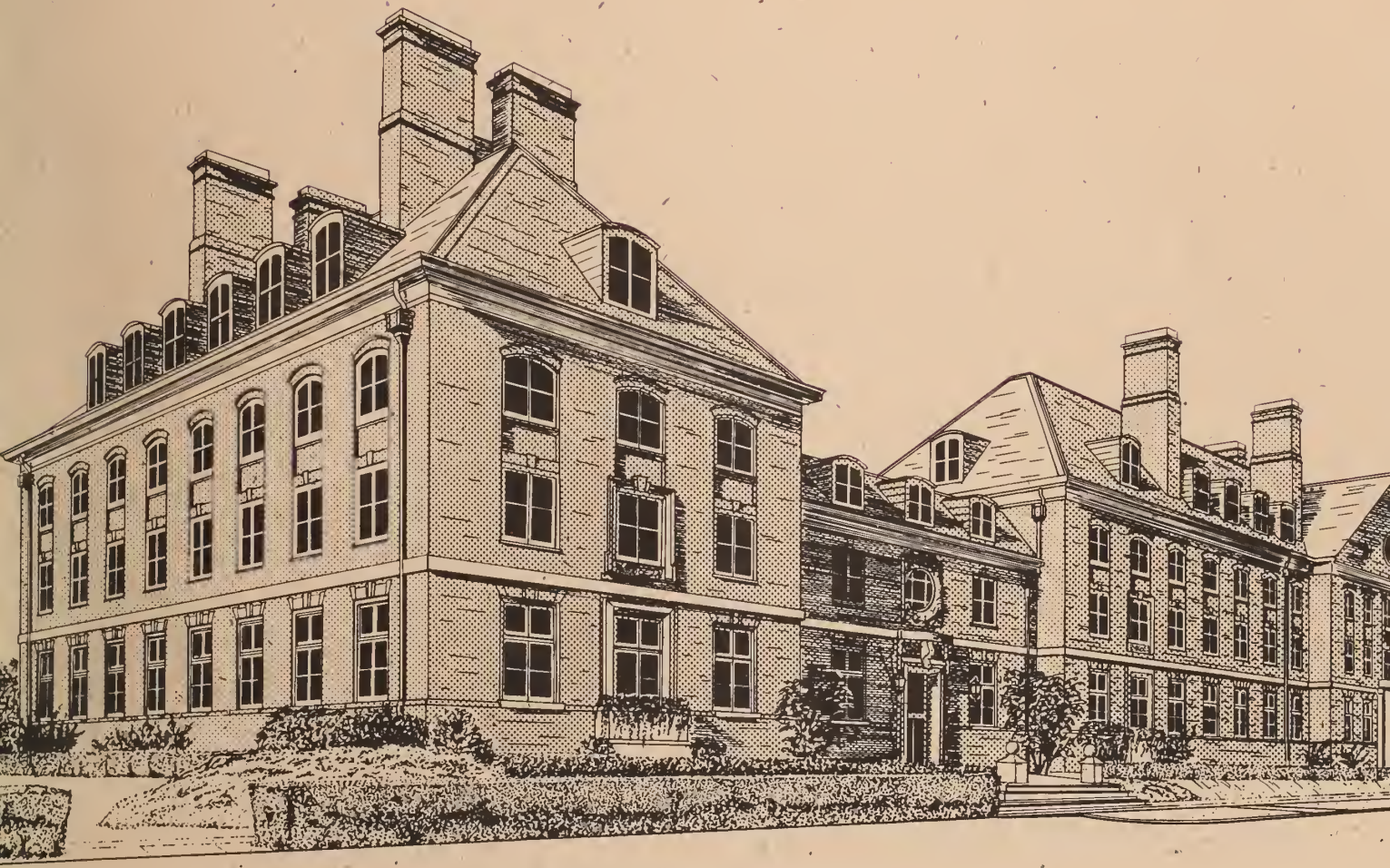


# Illinois State Geological Survey Annual Report

July 1990 – June 1991

Illinois Department of Energy and Natural Resources
STATE GEOLOGICAL SURVEY DIVISION

# ANNUAL REPORT TO THE BOARD OF NATURAL RESOURCES AND CONSERVATION

June 1990 to July 1991



Digitized by the Internet Archive
in 2012 with funding from
University of Illinois Urbana-Champaign

http://archive.org/details/annualreporttob9091illi

## CONTENTS


**1990-1991 HIGHLIGHTS AND SUMMARY** 1
**MINERAL RESOURCES** 17
Illinois Mineral Industry in 1989 and 1990 17
**Coal** 17
Coal Database Management 19
Coal Mining Geology 20
Coal Resources 20
Coal Characterization 21
Coal Cleaning: Physical and Microbial 22
Coal Cleaning: Chemical and Thermal 24
Coal Combustion 24
Fuels and Chemicals from Coal 25
Liquids and Gases from Coal 26
Technical Support Services 27
Coal Analysis Laboratory Services 27
Technology Transfer and Information Services 28
**Oil and Gas** 29
Oil and Gas Program for Illinois 29
Oil and Gas Statistics 29
Improved Oil Recovery Methods and Concepts 30
New Exploration Methods and Concepts 34
Hydrocarbon Generation and Migration Studies 35
Oil and Gas Database Management 35
Technology Transfer and Information Services 35
**Other Energy Sources** 36
**Groundwater Resources** 37
Groundwater Assessment 37
Technical Assistance 38
Technology Transfer and Information Services 39
**Industrial Minerals** 39
Mineral Resource Assessments 40
Limestone and Dolomite Resources 43
Silica and Industrial Sand 43
Clay Mineralogy and Clay Resources 44
Fluorspar and Metal Resources 44
Beneficiation/Processing 44
Technology Transfer and Information Services 44
**Mineral Economics** 45
Applied Economic Research 45
Technology Transfer and Information Services 45

**ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY** 49
**Environmental Studies and Assessment** 49
Special Siting Studies 49
Environmental Impact Studies 50
**Geology for Planning** 50
County Regional Studies 50
**Lake Michigan Coast and Basin Studies** 51
Lake Michigan Database Development 52
Coastal Erosion Studies 52
Lake History Studies 52
**Wetlands, Rivers, and Interior Lakes** 53
**Groundwater Protection** 54
Technical Assistance 55
Pesticides in Groundwater 55
Groundwater Assessments 57

**Waste Management** 58
Landfill Siting 58
Hazardous Wastes 59
Low-Level Radioactive Wastes 59
Coal Wastes 60
Technology Transfer and Information Services 60
**Earth Hazards and Geotechnical Studies** 61
Radon 61
Landslides 61
Earthquakes 61
Mine Subsidence 62
Rock Mechanics and Geotechnical Support Studies 63
Technology Transfer and Information Services 63

**GENERAL AND BASIC RESEARCH** 67
**Geologic and Topographic Mapping and Remote Sensing** 67
Geologic Mapping 67
Topographic Mapping 71
Remote Sensing 71
**Crustal Studies** 71
Potential Field Data 72
**Basin Analysis** 72
Framework Studies 72
Structural Geology and Tectonic History 73
Stratigraphy 73
Paleoenvironmental Studies 75
Synthesis 75
Technology Transfer and Information Services 77
**Quaternary Investigations** 77
Framework Studies 77
Quaternary Environments and Processes 78
Technology Transfer and Information Services 78
**Basic and Fundamental Hydrogeologic Investigations** 80
Hydrogeology Processes 80
Hydrogeology Research Laboratory Studies 81
Field Laboratory Studies 81
**Paleontology/Palynology Investigations** 81
Paleontology Studies 82
Palynology Studies 82
Technology Transfer and Information Services 83
**Geochemical Investigations** 84
Coal Geochemistry 84
Shale Geochemistry 84
**Mineralogic Investigations** 84
Research Studies 85
XRD Laboratory Improvement for Mineral Analysis 85
Technology Transfer and Information Services 86
**Computer Research** 86
Programming and Data Entry Research 86
Computer Systems 86
Technology Transfer and Information Services 87
**Scientific Support Services** 87
Quality Assurance/Quality Control 87
Analytical Chemistry Services 88
Isotopic Geochemistry Services 88
Inter-Survey Geotechnical Laboratory 89
Computer Services 89
**Database Enhancement** 89

**TECHNICAL AND ADMINISTRATIVE SERVICES** 93
**Technical and Administrative Services Branch Office** 93
**Business and Financial Services** 93
**Grants and Contracts** 94
**Human Resource Office** 94
**Library/Map Room and Public Information** 95
Information Office 95
Mail Room 95
Library/Map Room 96
Earth Science Information Center 97
Duplicating Services 97
**Public Liaison** 97
**Publications, Graphics, and Photography** 98
**Technical Design, Operations, and Maintenance** 102
Woodworking Shop 104
Machine and Metal-Working Shop 104
Electronics Shop 104
Drill Rig 104
Automotive Section 104
Applied Research Laboratory Shop 105
**Educational Extension** 105
Geological Science Field Trips 105
Teacher Workshops 105
Displays 105
**Geological Records and Samples Library** 106
Geological Records Unit 106
Geological Samples Library 108
**FY 1991 Capital Projects** 109

**HONORS AND AWARDS** 112
**ACTIVITY MEASURES** 115
**FINANCIAL REPORT** 118

*Printed by authority of the State of Illinois/1991/400*

## 1990-1991 HIGHLIGHTS AND SUMMARY

Significant issues facing the State of Illinois continued to receive the attention of the Illinois State Geological Survey:

*Economic development and jobs*—growth of Illinois' mineral extraction and service industries

*Energy*—adequacy of domestic liquid hydrocarbons for transportation and availability of coal resources for energy security

*Water*—access to adequate supplies of groundwater and protection of these supplies from contamination

*Clean air*—reduction of atmospheric emissions from coal combustion

*Land/wetlands*—wise use, relative values, and relative risks

*Minerals*—access to adequate supplies of construction materials to build or rebuild Illinois' infrastructures

*Facilities and infrastructures*—need for information to site new facilities and avoid hazards in the construction of Illinois' infrastructure

*Agriculture*—protection of prime farmlands

*Public safety and health*—identification and minimization of geologic risks from natural and manmade hazards.

The Illinois State Geological Survey (ISGS) continued its role as a scientific and information agency. In addition to responding to thousands of queries in person or over the phone, the ISGS contributed to major publications that focused on the Illinois Basin: the *Interior Cratonic Basins* published by the American Association of Petroleum Geologists, a major work on the Mahomet-Teays Valley published by the Geological Society of America, the first Bulletin published by the ISGS in 16 years, and the publication of 306 maps and reports.

### MINERAL RESOURCES AND ENGINEERING

The total value of minerals production in 1990 was about $2.7 billion. Coal, oil, and industrial minerals all increased in value for the first time in a decade.

#### Coal

• Assessing the impact of the Clean Air Act, the ISGS acquired information that seven mines filing contracts with the Federal Energy Regulation Commission (FERC) claimed to have coal with sulfur contents equivalent to 1.5 to 2.5 lbs $SO_2$/million Btu; thus they are capable of delivering coal that meets the interim standard until January 1, 2000, when emissions will be limited to 1.2 lbs $SO_2$/million Btu for all utilities. None met the more stringent 1.2 lbs $SO_2$/million Btu limit.

• A magnetic tape of data on the sulfur contents and heating values of Illinois coals has been obtained from the Energy Information Administration (EIA) of the U.S. Department of Energy. The data cover recent contracts signed between Illinois coal companies and electric utilities. Of the 1,320 contracts included in the tape, only one is for coal that meets the most stringent federal clean-air standard of 1.2 lbs $SO_2$/million Btus, whereas 118 contracts cover coal that meets the less severe standard of 2.5 lbs $SO_2$/million Btus. Both the FERC data noted above and the EIA information support increases in ISGS efforts to develop processes for removal of sulfur from coal and from stack gases after combustion.

• Stratigraphic data on coal and coal-related strata from more than 10,000 drill holes were added to the Coal Stratigraphic Information System, thus bringing the total to more than 30,000 stratigraphic descriptions of borings, outcrops, and mine exposures.

• A pilot study to evaluate the availability of coal resources in Illinois was based on selected quadrangles. Preliminary results from the first study area, the Middletown Quadrangle north of Springfield, indicate that less than 60 percent of the coal resources are available for mining and possibly less than 25 percent may be recoverable.

• The map, "Features Associated with the Springfield Coal Bed in the Illinois Basin," was compiled from data collected by the Illinois, Indiana, and Kentucky Geological Surveys. The map illustrates the outcrop of coal, mines, channels, and faults.

• The organic-sulfur content of maceral particles proved to be more variable than previously thought. SEM-EDX results to date confirm that the organic sulfur content is enriched in each maceral group where the coal underlies a marine shale.

• A project supported by the Center for Research on Sulfur in Coal is investigating the gaseous species of chlorine and sulfur in combustion gases. In preliminary results using Fourier Transform Infrared analysis in conjunction with thermogravimetric analysis, the species COS (carbon oxysulfide) has been identified in combustion gases from one Illinois coal. This species, by reacting with iron to form iron monosulfide, could play an important role in corrosion of utility boilers.

• Most of the chlorine found in handpicked, pure vitrain samples occurs in the organic matter, not in the ash-forming materials. It appears that the chlorine is held at nitrogen sites in the organic matter.

• Film flotation tests, developed at the University of California in Berkeley, have been found useful to predict and compare the flotation behavior of different coals and estimate the degree of oxidation of coals of the same origin.

• Results indicate that the pelletization of fine coal with calcium hydroxide, a sulfur-capturing sorbent, improves pellet compressive and impact strength and attribution resistance; it also waterproofs the pellet. Small-scale combustion testing indicates that up to 80 percent of the sulfur in the coal pellets can be captured upon combustion of the pellets at 850° C, which is the operating temperature for many fluidized-bed combustors.

• In-plant comparisons with subaeration cells indicate that column flotation may be an effective method for recovering fine coal from preparation-plant waste streams. A column flotation unit installed at Kerr-McGee's Galatia plant has consistently recovered more than 80 percent of the Btu content of the input materials, while rejecting 94 percent of the original ash and 55 percent of the original total sulfur.

• Five of seven difficult reagents tested at the ISGS were found to outperform a standard reagent used in the industry to separate coal from effluent wastes during flotation.

• Lignocellulose wastes generated by the Tennessee Valley Authority in its program, "Ethanol from Biomass," are being tested as binder material for pelletizing fine coal and char. The addition of the lignocellulose increases the total volatile matter content of the pellets. The pellets are a stoker-type feed, high in energy value, low in ash and sulfur values, and easy to handle. Lignocellulose produced from three sources—municipal wastes, and corn stalks, husks, and cobs—is being investigated in the development of marketable pellets.

• In a separate effort, a cleaning process involving leaching of wet ultrafinely ground coal and selective flocculation achieved up to 74-percent chlorine reduction, approximately 50-percent ash and pyrite reduction, and 90-percent Btu recovery for a high-chlorine coal sample. The results indicated that significant chlorine along with sulfur can be removed from coal using this process.

• Tests conducted on the three-step carbon monoxide-ethanol process of desulfurization in a continuous-feed mode did not result in significant reduction of sulfur. The disappointing results are apparently due in part to back-reactions that occurred in the single fluidized-bed reactor. A multiple-staged fluid-bed system may be more effective.

• The project to demonstrate desulfurization of Illinois coal using ethanol at the "proof-of-concept" scale is to be discontinued by August 31, 1991. Promising results reported in the fall by Ohio University scientists using the one-step process have not been duplicated at either the ISGS or at the University

of North Dakota Energy and Environmental Center (UNDEERC). Attempts to duplicate the Ohio University results are continuing at ISGS and at UNDEERC, and laboratory-scale studies of the patented one-step process will continue at ISGS.

• In the one-step process of coal desulfurization using ethanol in the presence of a reaction accelerator, batch experiments for 60-gram samples yielded sulfur reduction as high as 96 percent.

• A patent application covering the technology that produces a high-surface-area hydrated lime was filed with the U.S. Patent Office in July. Research Corporation Technologies has accepted the responsibility for patent prosecution, marketing, and licensing the ISGS investigation. With joint support from both the CRSC and DCCA, ISGS engineers designed and built a 20 to 100 pound per hour continuous process optimization unit to provide engineering and scale-up data for commercialization. Seven shakedown tests were successfully performed with the hydration reactor, resulting in more than 500 pounds of product.

• Shakedown tests of the main reactor for the Process Optimization Unit for production of high-surface-area hydrated lime indicate that properties of the materials produced are comparable to those produced in the earlier batch reactor. Two companies, Dravo Lime Company and Kennedy Van Saun, have agreed to contribute at least $50,000 each, mostly through in-kind services, in return for the right to participate in the development of the process. This level of industrial participation was a condition of the Technology Challenge Grant awarded earlier by the Governor's Science Advisory Committee.

• Tests indicated that the blending of coal with low-volatile chars may decrease the residence time and/or temperature necessary in a boiler to achieve acceptable combustion efficiencies of chars. Results suggest that the most effective way to achieve an acceptable level of combustion efficiency for chars is to increase the volatile matter content to 25 to 30 percent by blending with coal and to use slightly higher oxygen concentrations.

• With a modified ChemCoal process applied to a mixture of lignin and Illinois No. 6 Coal, ChemCoal solids with only 0.2 to 0.3 wt% ash and 0.6 wt% sulfur were produced. After analysis of 100 grams of these solids, Allison Gas Turbine Division of General Motors reported that lignin-augmented Illinois coal would make an excellent fuel for GM's coal-fired gas turbines, provided other conditions, including fuel price, are met.

• A char from mild gasification testing has been converted to a form that has both catalytic properties. Applications testing of the material by Amoco Research Center suggests that it is effective in adsorbing a wide range of compounds of concern to the U.S. Environmental Protection Agency.

• Chars with internal surface areas of 1,500 to 2,000 $m^2/g$, total pore and micropore volumes of 0.00 and 0.60 cm/g, respectively, and a micropore size distribution centered at 6 to 10Å have been produced from an Illinois coal. Although these chars have more than twice the internal surface area of conventional carbon and zeolite molecular sieves, it is unknown whether the pore structure can be further modified to achieve desired molecular sieve properties.

• Addition of lime to coal during mild gasification improved the hydrogen-to-carbon ratios of the oils produced, greatly reduced the evolution of hydrogen sulfide, and improved the combustion reactivity of the residual char as well as the oil API gravity and viscosity while having little effect on product yields.

• The Indiana Geological Survey is working with the Illinois Basin Coal Sample Program to replace the original Indiana coal sample in the IBCSP and add a second sample of coal from a seam that has commercial potential in both Indiana and Illinois. There were approximately 55 requests for 126 samples of Illinois Basin coal this year.

• In the Coal Analysis Laboratory, about 272 samples were analyzed for approximately 1,300 individual chemical analyses, and 129 particle-size determinations were performed.

**Oil and Gas**

• The $4.9 million, 4-year cooperative research program on Improved and Enhanced Oil Recovery Through Reservoir Characterization is in its third year. The project is providing information on hydrocarbon resources, reservoir characteristics, and production methods that will increase the recovery

of remaining mobile oil in existing reservoirs. The data are needed to design enhanced recovery programs. Transfer of new technology to industry and the public is a major component of the project. Representatives from industry and the U.S. Department of Energy (USDOE) have cited the Illinois program as a model for others to follow.

• Studies of the type and degree of reservoir heterogeneity in two of Illinois' oil-producing horizons, the Cypress and Aux Vases Sandstones, in 15 fields made substantial progress during the year. Ten studies are currently in various stages of completion in the matching USDOE/state program:

In the Bartelso field, studies have shown that only the lowermost producing Cypress sandstone exhibits sufficient lateral homogeneity to be efficiently drained with a 10-acre well spacing. Closer well spacing may be needed for the upper two producing Cypress sandstone units for optimal recovery efficiency.

Compartmentalization in the Aux Vases reservoir at King Field has allowed large areas to remain unswept by waterflood projects. An additional 1 to 2 million barrels of oil may be recoverable by targeted infill drilling and by selective well-designed waterflooding efforts.

In the Oakdale and Markham City North Fields study, the finding of clay minerals coating sand grains suggests that their presence may have prohibited precipitation of calcite cements. High permeability appears to be related to the presence of clay coatings, absence of calcite cement, and grain-size distribution.

In the Tamaroa Field, reservoir heterogeneity and pressure maintenance have been found to be controlling factors on cumulative production and ultimate recovery efficiency.

• A regional diagenetic sequence for reservoir development created for the Aux Vases Sandstone on the basis of data from seven fields indicates that similar depositional and diagenetic processes influenced the development of Aux Vases facies and reservoir quality over a wide region.

• The report, *Application of Old Electric Logs in the Analysis of Aux Vases Sandstone (Mississippian) Reservoirs in Illinois*, was published as ISGS Illinois Petroleum 134. The report provides a methodology to estimate porosity and water saturation from these logs.

• Oil and Gas Section Head, Donald F. Oltz, was among seven geologists who met in Dallas, Texas, to finalize a classification system for clastic and carbonate reservoirs in the United States. Products prepared at the meeting have been used by the USDOE to improve documentation of remaining U.S. oil reserves by reservoir class. These values are among the considerations used by the USDOE to plan the direction and emphasis of their oil and gas research program.

• The first of a series of computer-generated oil and gas development maps has been completed. The maps are available to the public in color or as diazo reproductions at a scale of 2 inches = 1 mile. Each map generally covers nine townships.

• New pressure-volume-temperature (PVT) instruments capable of performing standard PVT analyses and tests of phase behavior for enhanced oil recovery studies have been installed and calibrated. These instruments allow the ISGS to perform highly sophisticated measurements of porosity, permeability, and other reservoir engineering parameters at the actual pressures and temperatures encountered in oil reservoirs at depth.

• ISGS analyses of gas samples from a basement in which the sump had "caught on fire" identified the source as a leaky pipe connecting a propane fuel tank to the home rather than as drift gas, which is common in the area.

**Other Energy Sources**

• The Illinois, Indiana and Kentucky Geological Surveys are compiling available data on the New Albany Shale (Devonian and Mississippian) in the Illinois Basin for the purpose of estimating volumes of natural gas in place. The study is supported in part by a grant from the Gas Research Institute to the Illinois Basin Consortium.

• The ISGS supplied information to industry and others on coal-mine methane including data on coal-bed methane desorption and the thickness and depth of coal seams, as well as maps of abandoned coal mines.

**Hydrogeology**

• Several preliminary cross sections and draft bedrock topography maps have been constructed for Bureau, Henry, and Whiteside Counties as part of an aquifer assessment project. Maps of the thickness of aquifers and confining units, and of the potential for groundwater contamination are in various stages of preparation for the Prairie Aquigroup in these counties plus Lee and Rock Island Counties.

• In cooperation with the Illinois State Water Survey (ISWS), the ISGS is constructing geologic maps and cross sections of southern Cook County and Will County in order to delineate areas with extensive sand and gravel aquifers, especially those in contact with the Silurian-age bedrock. The information will be used by the ISWS to develop hydrologic models of the region and for forthcoming projects at ISGS.

• Electrical earth resistivity surveys to seek sand and gravel aquifers were conducted at 52 locations where previous drilling had failed to locate an adequate water supply. The ISGS received several letters of thanks from users of the service after they successfully located groundwater.

• The ISGS used its borehole logging equipment to assist the Illinois Departments of Transportation and Public Health in evaluating the construction of a 450-foot well at the Long Hollow Scenic Overlook. The well had been found to be contaminated by coliform bacteria and the cause was being sought. During FY91, 87 borehole logs were run at 66 sites for aquifer evaluation and for stratigraphic analysis. A new sonic sonde was purchased to increase ISGS capabilities.

• Responses to well drillers, farmers, citizens, industries, and governmental agencies desiring to locate, develop, use, or evaluate groundwater resources included about 1,400 phone calls, 150 letters, 66 groundwater possibility reports, and two preliminary evaluations of proposed waste disposal sites. Approximately 80 visitors sought information from the Groundwater Resources Section.

**Industrial Minerals and Metals**

• Several new maps and cross sections have been prepared as part of the Paducah CUSMAP project. They were used in developing preliminary mineral resource assessments and testing of various ore deposition models proposed and refined at a week-long series of meetings of representatives of the Illinois, Indiana, Kentucky, and Missouri Geological Surveys and the U.S. Geological Survey held in Champaign. The new CUSMAP products include

- maps of mines and prospects,
- a surficial deposits and stack map of sediments to a depth of 50 feet,
- a completely revised map of the morphology on the top of Precambrian crystalline basement in the Paducah Quadrangle,
- bedrock geologic maps,
- limestone, sand and gravel, and coal resource maps,
- three structural cross sections.

• The CUSMAP database was revised and updated for use as the basis for 24 mineral resource potential models that employ Geographic Information System (GIS) software on ISGS workstations.

• An exercise was held in late April through early May to evaluate the use of GIS for assessing the minerals potential within the Paducah Quadrangle by utilizing genetic models. The exercise represented the first successful use of GIS in the national CUSMAP program.

• Also as part of CUSMAP, a preliminary assessment of mineral commodities within the Paducah Quadrangle was carried out with the USGS in Denver in October and delivered to the U.S. Forest Service.

• A study on the nature of Paleozoic rocks in northeastern Illinois was completed using data derived from more than 100 cores drilled as a part of the Greater Chicago Tunnel and Reservoir Plan (TARP) project. The information should prove useful to the $100-million-per-year stone industry in the region.

• Northern Kankakee County has the potential to supply significant quantities of high-quality aggregate for local use and the Greater Chicago market. Three new quarries either have, or are about to be,

opened there. Available drill cores, outcrops, and existing quarry faces in northern Kankakee and southern Will Counties are being studied to determine the thickness, extent, and quality of Silurian carbonate rocks in the area.

• New information suggests that the basal configuration of Silurian reefs is ridge-like rather than conical. If so, Chicago-area reserves of high-quality aggregate are somewhat greater than previously thought.

• For better understanding of Illinois' tripoli deposits, the ISGS compiled a detailed map of a 3-square-mile area in Alexander County, descriptions of more than 100 mines and prospects, and studies of the mineralogy, chemistry, and petrography for peer review. The studies suggest that low-temperature hydrothermal fluids, in addition to in situ weathering, played an important role in the formation of these deposits.

• Two localities with potentially valuable deposits of kaolin in the Neda Formation, Maquoketa Group, have been identified recently. Available data and well logs are being analyzed to seek other possible occurrences.

• An advanced, kinetically balanced and rocking (AKBAR) grinding mill is being developed, tested, and compared with conventional tumbling mills in effectiveness and energy use. Grinding comparison tests of the AKBAR-ball mode of operation versus conventional rotating-mode operation indicate more efficient (less energy) operation of the AKBAR mill to achieve the same degree of comminution for both large and small particle sizes.

## ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY

### Environmental Assessments

• The second full year of a major statewide environmental property assessment program for the Illinois Department of Transportation (IDOT) resulted in completion of more than 130 reports representing 385 miles of state highway projects. Since the program began a little more than 2 years ago, 340 requests have been received and 273 completed reports have been delivered. Approximately 40 percent of the investigations identified potential hazards to IDOT construction projects.

• During the year, ISGS worked closely with the Illinois Department of Mines and Minerals (IDMM) in developing a GIS Mine Permit Review database. Funding for the coming fiscal year for the Lands Unsuitable for Mining Program has been substantially reduced by the federal Office of Surface Mining. As a consequence, the program to use the GIS to assist IDMM in mine permit review and analysis will be substantially reduced in FY92.

### Geology for Planning

• In cooperation with the Office of Solid Waste and Renewable Resources of the Illinois Department of Energy and Natural Resources (ENR), the ISGS is using the GIS to provide land-use planning assistance to Lake, McLean, and Will Counties. Similar assistance was provided to Champaign County.

• To put the data from the former Superconducting Super Collider study into more usable and available form for industry, local governments, and the general public, the ISGS is issuing a series of reports and maps on the area involved in that study. Three publications highlight the distribution of Paleozoic rocks in northeastern Illinois and implications for subsurface aggregate mining, the improved understanding of the subsurface from seismic reflection and refraction surveys, and the geotechnical properties of deposits in the region. Open file reports now available include *Kane County Water Well Database*, *Key Stratigraphic Control*, *SSC Bibliography and Archival Listing*. Six open-file maps at a scale of 1:62,500 were completed including *Bedrock Topography of Kane County*, *Drift Thickness of Kane County*, *Earth Materials of Kane County*, *Soil Drainage Characteristics of Kane County*, *Thickness and Distribution of Tiskilwa Till in Kane County*, and *Stack-Unit Map of Kane County (to a Depth of 50 Feet)*.

### Lake Michigan Coast and Basin Studies

• More than 1,000 color transparencies were added to the ISGS Lake Michigan shoreline documentation library.

• During late summer, field crews resurveyed more than 30 percent of the Illinois shoreline to provide control for shore maps. Bathymetric mapping for the north half of the Chicago nearshore area was com-

pleted with profiles at a 300-foot spacing. The detail far exceeds that of any previous general survey of the Chicago shore and extends 3,000 feet lakeward. About 1,000 color slides showing new construction, erosion, and conditions of old erosion scars of Lake Michigan shores were shot in December. This brings the number of historic aerial and ground photos of the Lake Michigan shore to more than 70,000.

• Bathymetric surveys to monitor lake-bottom changes in the vicinity of North Point Marina show that erosion is continuing as the nearshore area adjusts to changes in littoral sediment supply and transport caused by construction of the marina.

• Identification disks placed on the surface of Lake Michigan ice at Wilmette were recovered from beaches as far away as the Michigan shore. This demonstrates that ice rafting is capable of transporting Illinois sediment to the opposite shore of the lake.

• Monitoring of the conditions that were inadvertently created for the development of a logarithm-spiral beach in the area is providing information on rates of erosion and the geometry of coastal changes downdrift from shore structures. Monitoring has also allowed evaluation of interim shore defenses now protecting a marina parking facility.

• Processing seismic-reflection profiles of the bottom of Lake Michigan in the vicinity of the early Holocene forest site that yielded 8,300-year-old tree stumps have revealed ancient stream channels that eroded as much as 6 meters into the glacial till forming the lake bottom.

• Major coastal erosion and longshore transport during the past 3,000 radiocarbon years along what is now the central Chicago shoreline have been shown to be critical in the development of the drainage pattern of the modern Chicago River and the location of its mouth.

• With funding from the Federal Emergency Management Agency, the ISGS has acquired and computer-processed additional historical data on the positions of shorelines and bluffs. The data have been used to estimate erosion rates of the Lake Michigan shoreline. Control points are being precisely located to carry out computer mapping from aerial photographs.

• Several detailed bathymetric maps of the nearshore area of Chicago were completed and are being used as bases for mapping of the lake-bottom materials for the Illinois Department of Conservation (IDOC). These maps are designed for use by IDOC in the management of Illinois' Lake Michigan Fisheries. A 1:120,000-scale map has also been produced, showing all reefs that have been studied (and the reports published) as well as the reefs that have been newly identified.

• During sediment sampling for lake-bottom material mapping, zebra mussels were collected from a gravel bed at Jackson Harbor. This is the first known occurrence of the pest in any of Chicago's small boat harbors. Later, zebra mussels were also discovered in the vicinity of the 59th Street, Diversey, and Montrose Harbors. All occurrences were promptly reported to IDOC, the Natural History Survey, and the Illinois-Indiana Sea Grant Office in Oak Brook.

**Rivers, Backwater Lakes and Wetlands Research**

• Sediment accumulation rates and sediment quality have been determined for parts of the Grand Calumet River. The sedimentation rates vary from less than 0.1 cm/year to 5.8 cm/year. In the upper 1 foot of sediment in the five cores taken, the concentrations of toxic elements (cadmium, copper, nickel, zinc, and lead) are at heavily polluted levels, according to published guidelines. They are highest in the Indiana section of the river in sediments deposited in the 1950s.

• Wetland studies are underway in several areas to understand the hydrogeological settings, erosion/deposition patterns, and assess the impact of watershed development on vegetation and hydrology of fens and associated wetlands and to determine what, if any, options may be used to minimize adverse effects of urbanization on wetland complexes.

• In one constructed experimental wetland area, results of hydrogeological monitoring show that two ponds recharge the groundwater and two ponds receive a net discharge of groundwater.

• Studies of a pristine fen in northern Illinois have shown that elevated concentrations of Cl, Na and $NO_3$, possibly from the discharge of a septic system drainage field, have promoted growth of cattails,

to the detriment of typical fen species. The fens are the discharge areas for all groundwater in the watershed.

• Data are being collected to develop a computer model of a wetland in the Black Partridge Forest Preserve of Cook County. The model will be used to investigate the possible effect of a proposed highway drainage system on the hydrology of the wetland.

**Groundwater Protection**

• The last of the required reports and cross sections illustrating the relationship between stratigraphy and estimated water quality for 19 oil-producing counties and 10 adjacent counties were delivered to the IDMM in March. The data are being used by IDMM to assist in their enforcement of the requirement to case oil wells through potential underground sources of drinking water.

• Maps showing drainage basins, bedrock lithologies, geomorphologic indicators, and overburden thickness are being developed for the karst regions of southwestern Illinois to help minimize agrichemical contamination of the unconfined aquifer in the three-county area.

• Woodstock, Illinois, was selected by the ISGS and ISWS in cooperation with the IEPA, for a detailed pilot study to establish the methodology for a needs assessment to be used in evaluating aquifer characteristics and defining the potential for contamination.

• Preliminary versions of cross sections, isopach maps of four aquifers, a stack-unit map to a depth of 100 feet, and a map depicting the contamination potential of aquifer materials have been compiled for the Woodstock 7.5-minute Quadrangle—all part of a demonstration of a Groundwater Protection Needs Assessment. Statistical analysis of the chemical data is underway and draft reports are in preparation.

• In a pilot study, the ISGS is assessing the occurrence of agrichemicals in rural private wells in five representative hydrogeologic regimes in the state. Sampling and analysis of 240 well-water samples for 39 agrichemicals and nitrate and nitrite were completed during the fiscal year.

• In a separate study, the ISGS is cooperating with the Illinois Department of Agriculture and the Cooperative Extension Service (University of Illinois at Urbana/Champaign) in a statewide survey to provide statistical estimates of the occurrence of agricultural chemicals in rural private wells. Sampling of 340 randomly selected wells began in March 1991.

• To estimate the relative contributions of surface water runoff and groundwater discharge to pesticide loadings in streams, the ISGS is investigating the subsurface movement of atrazine and deethylatrazine in a small watershed. Samples of groundwater, tile drainage water, and stream water were collected three times before application of atrazine and for 12 weeks after application. Detailed chemical analyses are not yet complete; however, preliminary results suggest that the extent of atrazine adsorption in deeper materials with low organic carbon is greater than that predicted on the basis of the organic carbon content.

• The ISGS is providing technical assistance to the Illinois Department of Agriculture in the screening of 60 randomly selected agrichemical facilities and in the preparation for the environmental site assessments made by contractors at 20 such facilities. This sampling and assistance is part of IDOA's effort to develop guidelines for action and estimate the long-term costs of dealing with the potential problems posed by contamination of soils by pesticides at the approximately 1,300 agrichemical facilities in the state.

• Results of monitoring pesticides in drainage tile effluent demonstrate that pesticide concentrations in the effluent can be used to evaluate the field-scale leaching of these compounds, provided certain information is known regarding the tile system layout and local hydrogeology.

• A paper has been prepared on how to assess the contamination potential for aquifers using available data on texture of surface sediments, nature of underlying bedrock, drift thickness, and presence of known drift aquifers.

• The map, *Potential for Aquifer Recharge in Illinois* (developed during the previous report period), was printed in September 1990.

**Waste Management**

• The mapping completed for Champaign County in the spring of 1990 was used by the Intergovernmental Solid Waste Disposal Association to identify five potential landfill sites. Test drilling on two of the sites chosen by the Association indicate that both sites may be geologically suitable.

• Results from an extensive database of more than 8,000 wells in Lake County indicate that a large part of the study area in this county is underlain by thick sand and gravel deposits beneath clay-rich surficial tills. Results of the mapping have been discussed with Lake County staff, who are currently determining siting criteria for a new sanitary landfill and composting facility.

• The final report, *Investigation of the Hydraulic Effects of Deep Well Injection of Industrial Wastes*, was issued in November, and the ISGS continued to provide technical expertise and advice to the Illinois Environmental Protection Agency (IEPA) and the USEPA, Region V, in the Class I Underground Injection Control Program. Reviews were provided on three petitions for the continued injection of hazardous wastes, one mechanical integrity test, and a groundwater monitoring plan.

• The mobility of cadmium and lead in leachates from municipal waste incinerator ash is being investigated in the laboratory. Samples of a bottom ash, a fly ash, and a combination of the two were extracted with water under various pH and other conditions. The capacity of illite and kaolinite to adsorb cadmium and lead from the various extract solutions was then tested with batch adsorption/attenuation procedures. Preliminary results indicate that both pH and the concentrations of competing ions affect the ability of the clay minerals to adsorb/attenuate cadmium and lead from the extracts. Results of these studies will be useful in managing and disposing of municipal waste incinerator ash.

• ISGS staff continue to provide technical assistance, including the construction of computer-generated three-dimensional models useful in characterizing and visualizing the proposed site for the low-level radioactive waste (LLRW) disposal facility. In addition to providing a rigorous technical review of both the draft and final site characterization reports for the Martinsville Site, some ISGS staff members will be called to testify at the hearings now being held by the LLRW Siting Commission hearings. The Martinsville site has been judged by ISGS staff as adequately characterized.

• Nearly 50 persons representing 12 counties and two multicounty agencies from as far away as Alexander and Carroll Counties participated in a workshop on use of the Geographic Information System (GIS) and geologic mapping in landfill siting held at the Natural Resources Building in early May 1991. Several counties expressed an interest in participating in the landfill siting assistance program of the Illinois Department of Energy and Natural Resources.

**Earth Hazards and Geotechnical Studies**

• An inventory of landslides along the Ohio and Mississippi Rivers is being conducted to produce a risk assessment valuable for disaster planning.

• Possible earthquake-induced liquefaction features are being investigated in cooperation with scientists from the U.S. Geological Survey (USGS). Although some features appear to be related to the 1811-1812 earthquakes, others appear to be considerably older. Detailed work including stratigraphic analysis of the key sites will be needed to identify the origin, age, and areal extent of the liquefaction features.

• Some permanent lateral movements of as much as 15 inches have been recorded in monitoring shallow, three-dimensional, near-surface displacements due to mine subsidence. Hydrogeologic impacts due to subsidence over the same longwall panels have been found to be minimal in the glacial materials, usually the only groundwater supply in the area. Agricultural yields at mitigated sites were depressed in 1990 because of the wet spring weather.

• The Illinois Mine Subsidence Research Program has been funded for FY92 by the Coal Development Board. Research projects will continue at the ISGS, Northern Illlinois University, Southern Illinois University, and the University of Illinois at Urbana-Champaign.

• To help evaluate the potential for mine subsidence, the ISGS published the report, *Proximity of Underground Mines to Residential and Other Built-up Areas in Illinois*, as Environmental Geology 138.

• More than 4,100 records of claims are now in the computer-assisted Directory of Mine Subsidence Insurance Claims.

## GENERAL AND BASIC RESEARCH

### Geologic Mapping

• The report, *Geologic Mapping for the Future of Illinois*, was prepared in response to Senate Resolutions 86-881 and 87-98. It includes a detailed analysis of mapping needs and prioritizes the 1,073 7.5-minute quadrangles in the state for mapping. Only 3 percent of the state has been mapped at this scale. An estimate of the cost for completing the mapping in Illinois was provided.

• A benefit/cost study, completed to accompany the report to the Senate, used a mapping program in Boone and Winnebago Counties to demonstrate most likely benefit/cost ratios of 12 to 27 for that effort. When the analysis was expanded to the entire state, the most likely benefit/cost ratios ranged from 3 to 7. The benefits of geologic mapping in Illinois clearly justify the proposed geologic mapping effort.

• The geologic maps and report on the Creal Springs, Eddyville, and Stonefort 7.5-Minute Quadrangles have been printed. The maps were released in the second half of 1990. The report to be released in the summer of 1991 is the first new publication in the Bulletin series since 1975. Final color proofs of the Goreville and Waltersburg 7.5-Minute Quadrangle maps were produced during the report period. Other 7.5-minute quadrangle maps are in various stages of preparation and completion.

• Two new COGEOMAP projects, one in southern Illinois and one in the vicinity of Champaign, were funded by the USGS and will begin as soon as final contract documents can be completed.

• A new technique for displaying three-dimensional map data using colors in combination with line and dot patterns has been devised.

### Crustal Studies

• Aeromagnetic and gravity maps have been compiled for the whole state through the cooperation of the USGS and ISGS. Two seismic reflection sections in southern Illinois were acquired and interpreted, thus allowing new insights into the structural framework of this area and the evolution of the Illinois Basin.

### Basin Analysis

• Recently acquired seismic profiles and other data indicate that a west-northwest-trending Early Proterozoic crustal domain boundary underlies the 1.48-billion year-old granite rhyolite terrain in southern Illinois.

• The first three regional cross sections covering the Illinois Basin have been completed and are available as diazo reproductions from the ISGS Open File Series. They provide a structural and stratigraphic framework illustrating basin architecture and the development of sedimentary sequences.

• Preliminary chemical data indicate that the two thickest and most widespread Ordovician-age K-bentonite beds in eastern North America can be correlated with similar ash beds in Europe. This provides a direct time-stratigraphic tie between the Ordovician sections of the Illinois Basin and those elsewhere in the world.

• A study was initiated to examine the nature and distribution of the Caseyville Formation, a unit deposited on the deeply eroded land surface that was exposed during a significant drop in relative sea level during late Mississippian to early Pennsylvanian time.

• Biostratigraphic correlations, made on the basis of conodonts and supplementary evidence of fusulinids and ammonoids, allow the correlation of major eustatic cycles from Texas to the Midcontinent to the Illinois Basin.

• The volume, *Interior Cratonic Basins*, was published in May 1991 by the American Association of Petroleum Geologists as Memoir 51. About one-half of the volume is devoted to the Illinois Basin as a prototype.

• A program plan to integrate and coordinate research activities has been developed and accepted by the member surveys of the Illinois Basin Consortium.

• The ISGS participated in the development of the manuscript, "Structure and Chronology of Part of the Pennyrile Fault System, Western Kentucky." This paper outlines the development of one of the major fault systems in the southern part of the Illinois Basin.

**Quaternary Investigations**

• The Geological Society of America published a major compendium on the Teays-Mahomet Bedrock Valley, which contains a major groundwater aquifer of the Midwest. John Kempton was co-editor.

• A silt deposit in western Illinois has been shown by paleomagnetic and stratigraphic evidence to be more than 800,000 years old, making these sediments the oldest known Quaternary sediments in Illinois.

• Other Quaternary investigations focused on the Martinsville low-level radioactive waste site, the Quaternary framework of the Lake Michigan region, and Quaternary deposits along a segment of the Illinois River, the Lake Fork Sangamon River, and the Wabash Valley.

**Hydrogeological Investigations**

• During the almost 3 years of monitoring a field-scale soil liner, measured infiltration fluxes through the compacted clays ranged from 8.1 to $1.5 \times 10^{-8}$ cm/s. All calculated, saturated, hydraulic conductivities based on fluxes and gradients measured in the liner are significantly less than the recently enacted Illinois regulations that call for conductivities of no more than $1 \times 10^{-7}$ cm/s.

**Geochemical Investigations**

• Concentrations of Mn, Fe, and Sr in calcite in cleats indicate that the mineral was precipitated from solutions within the range of composition of typical formation waters, but different from seawater. The data may help to shed light on the timing and causes of this secondary mineralization in Illinois coals. The calcite compositions were determined using synchrotron X-ray fluorescence at the Brookhaven National Accelerator Laboratory in New York.

• Published data show that systematic variations of pyrite sulfur, degree of pyritization, and amount of carbon in the New Albany Shale Group are related to environments of shale deposition.

**Paleontology/Palynology Studies**

• Palynology studies have proven that several sandstones of nonequivalent ages have been called "Boskydell Sandstone." The term should be dropped for these units and the term "fossiliferous marine facies" should be used, followed by the name of the sandstone.

• A manuscript supporting the conclusion that major floral changes in the Middle-Upper Pennsylvanian were due to seasonal drying brought on by major glaciation in the Southern Hemisphere and changes in wind and ocean currents is being prepared. No evidence for a catastrophic extraterrestrial event such as occurred at the Cretaceous-Tertiary boundary has been found.

**Mineralogic Investigations**

• Recent efforts have shown that the variety and amount of mixed-layered, kaolinite-expandable clay that forms in soils is a reflection of the duration of weathering.

• Berthierine, a rare clay mineral, has been found in Native American artifacts from northwestern Illinois. The occurrence suggests that the geological source of this material is from around Sterling, Illinois.

**Computer Research**

• For the CUSMAP mineral assessment workshop held in spring, the ISGS computer staff prepared maps and model results as the workshop participants refined and developed models. The project will continue to use methods developed during the workshop to complete models for a meeting in 1992.

• The poster, "Multilevel GIS Applications at the Illinois State Geological Survey," placed second in the "Most Analytic" competition against several hundred posters at the International ARC/INFO Users Conference.

### Scientific Support Services

• The Isotope Geochemistry Laboratory performed carbon and oxygen isotope analyses on 602 samples, sulfur isotope analyses on 342 samples, and D/H determinations on 521 samples. Radiocarbon age determinations were performed on 115 samples provided by scientists from throughout Illinois.

## TECHNICAL AND ADMINISTRATIVE SERVICES

Vital functions supporting ISGS research and service programs included

- budgeting
- accounting
- financial reporting
- contract/grant preparation and monitoring
- timekeeping
- counseling staff
- receiving and distributing mail and equipment
- processing orders
- shipping publications and other materials
- maintaining Information Office
- handling inquiries
- distributing educational materials
- overseeing legislative relations
- fabricating, maintaining, repairing scientific and office equipment
- overseeing automotive operations
- arranging telecommunications
- providing editing, graphics, typography, and photography
- duplicating publications
- planning and supervising construction and renovations

• The Geological Records Unit, Geological Samples Library, and the Reference and Map Library continued to serve at the heart of ISGS activities and as a basic source of information for private industry, government agencies, and the general public.

### Business and Financial Office

• The Business and Financial Services Unit (BFSU) went online with the Group Insurance System and automated reporting to the State Universities Retirement System and implemented other computerized reporting systems for more effective financial control and reporting procedures.

• The BFSU also designed and implemented a travel-reporting system.

• The BFSU participated in two internal Fiscal Control and Internal Auditing Act audits and one external biennial audit without material findings.

### Human Resources Office

• New hiring procedures were implemented during the fall of 1990 by the Human Resource Office (HRO). Among its activities, HRO conducted 85 searches and processed paperwork for 72 new staff members (eight on State General Revenue Funds and 64 on contract funds).

### Public Information Unit

• A new automated accounting system was installed in the Public Information Office to provide for integrated networked sales and inventory listings.

• In the mail room, the number of orders filled increased by 1,822 over last year's tally. The number of ISGS publications distributed and pieces of mail distributed also showed significant increases.

• The Earth Science Information Center responded to 563 requests from the public for geodetic and cartographic information.

### Publications, Graphics, and Photography Unit

• Major format graphics were in high demand. Final products included three cross sections of the Illinois Basin, four plates of stratigraphic columns and cross sections to accompany CUSMAP's bedrock geology maps, two cross sections of the proposed low-level radioactive waste disposal site at Geff in Wayne County, numerous cross sections for the Groundwater Resource Section's commitment to IDMM, significant contributions to Illinois Geologic Quadrangles 4-6, and a major plate for Bulletin 96.

• Bulletin 96, *Geology of the Eddyville, Stonefort, and Creal Springs Quadrangles, Southern Illinois*, the first ISGS Bulletin to be published since 1975, came out in 1991. The new format, created by the graphics staff, is attractive and cost effective—designed to be reproducible in the ISGS Duplicating Shop.

**Public Liaison**

• News of research and service efforts at the ISGS was disseminated in part through a mini-annual report written especially for the public. Exhibit displays were also prominent at a number of public functions including the DuQuoin State Fair, fall and spring county officials' meetings, a Board of Natural Resources and Conservation meeting, a Nature of Illinois Foundation meeting for media in Chicago, Earth Day Weekend, and annual meetings of the Geological Society of America, Illinois Science Teachers, and Illinois Aggregate Producers.

**Technical Design, Operations, Maintenance**

• A total of more than 430 internal work orders for repairs, fabrications, maintenance, moving, and other services were completed during this period.

**Educational Extension**

• Four public field trips sponsored by the ISGS attracted 492 participants to scenic and geologically significant areas of Ogle County, Nashville, Fairfield, and Kewanee, Illinois.

**Geological Records and Samples Library**

• The Geological Records and Samples Library was transferred from the Mineral Resources and Engineering Branch to the Technical and Administrative Services Branch on April 16, 1991.

• The Water Well Data Task Force is continuing to make substantial inroads against the backlog of unprocessed records dating back to 1988. The Task Force processed 19,733 records during the reporting period.

• Since the Illinois Department of Mines and Minerals (IDMM) stepped up its enforcement of records lodgement requirements, more than 4,500 records that had not previously been supplied have been received and processed.

• Visitors and staff to the Geological Samples Library referred to the files 224 times and studied 632 sets of samples or cores.

**Capital Projects**

• An upgrade of laboratories and facilities in 20 rooms is continuing with the release of $630,000 of capital development funds.

**Activity Measures**

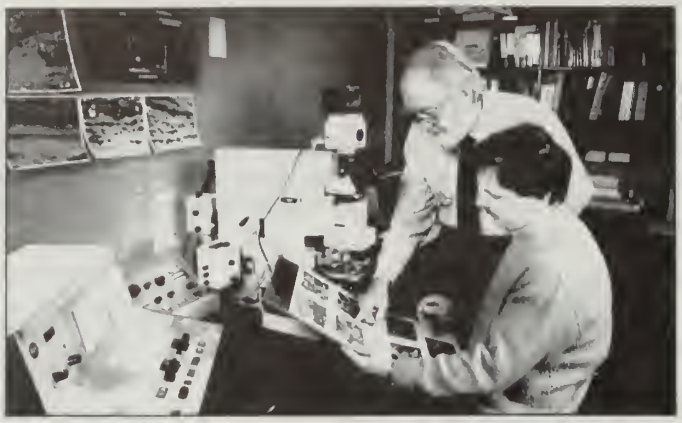
• ISGS scientists reported 130 state-funded research projects and 82 sponsored research projects were in progress in the past year.

• The ISGS issued 306 new reports and maps and distributed 27,741 copies of ISGS publications.

• The ISGS received or held conferences for 6,031 people, provided 1,491 responses to letter inquiries, gave more than 525 talks, poster sessions, displays, and reviews, and participated in more than 190 workshops, classes and seminars. Facsimile responses to inquiries (not listed above) increased markedly.

• An active program of information dissemination and technology transfer was maintained by the ISGS, supporting its scientific activities and enhancing its reputation as an information agency as well as a scientific research and service organization.

A



B



C



D



(A) Dick Harvey (standing) and Ilham Demir, Coal Section, examine their photomicrographs of coal. (B) Phil Reed, Hydrogeology, lowers a sonde into an observation well to determine the sequence of earth materials at Martinsville. (C) Petroleum geologist Bob Cole labels a sandstone core sample taken from a Cypress outcrop. (D) Minerals engineer David Rapp uses a press to produce a pellet of coal and calcium hydroxide. (E) In Macoupin County, geologist Phil DeMaris clears a coal exposure to examine the roof shale contact. (F) Barb Stiff, GIS specialist, and geologists Mike Sargent (seated) and Jim Baxter examine a map showing potential fluorspar veins in Illinois. Assessment maps for about 20 commodities and many intermediate maps are being produced digitally for display in January 1992 at the Paducah CUSMAP meeting in St. Louis.

E

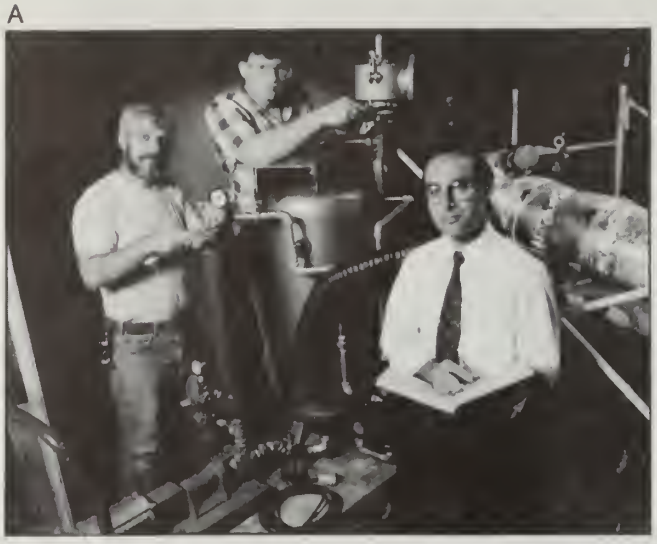


F



# Mineral Resources Research and Service

A



B



C



D



(A) Jimmy Cooper (from left), Dave Moran, and Massoud Rostam-Abadi, Minerals Engineering, get ready to prepare a batch of high-surface-area hydrated lime. (B) Geologists Colin Treworgy and Margaret Bargh of the Coal Section work on an Illinois Coal Mine Map of St. Claire County. (C) Strip mining at the Arch of Illinois Captain Mine in Perry County. (D) Irma Samson, Mineral Economics, registers a participant at the Illinois Mining Institute convention. (E) Donald Oltz, head of Oil and Gas, assists Dennis Haggerty, petroleum engineer, in taking a core sample from a Cypress sandstone outcrop for lab analysis.

E



# MINERAL RESOURCES

## ILLINOIS MINERAL INDUSTRY IN 1989 AND 1990

Mineral production in Illinois increased 5.8 percent in value in 1990, according to preliminary figures (table 1). The total value of mineral production in 1990 was about $2.7 billion. The values of coal, oil, and industrial minerals (fig. 1) increased together in 1990 for the first time in a decade.

The production of coal and industrial minerals increased, but oil and gas production fell in 1990. Coal production showed a small increase in 1990 after 4 years of decline. As a result of the Persian Gulf War, oil production fell slightly, but its price per barrel increased by more than 23 percent, which resulted in an overall increase of 20.5 percent in the value of oil produced.

Data on clay production supplied by the U.S. Bureau of Mines are preliminary and subject to substantial revision. The unusually high percentage of increase in clay production in 1990 cannot be explained at this time; however, changes in reporting procedures for certain materials such as Fuller's Earth could have caused the unusual increase. Apparently, there are no new clay operations in Illinois.

The end of the Persian Gulf crisis, the passing of amendments to the U.S. Clean Air Act, and an economic recession are expected to dampen the prospects for the mineral industry in Illinois in 1991.

## COAL

Illinois has the nation's largest remaining bituminous coal resources in the ground—about 180 billion tons—but most of this coal has a sulfur content much higher than western and eastern U.S. coals. Only about 10 billion tons have a sulfur content of less than 2.5 percent; little coal contains less than 1 percent. Coal with less than 2.5-percent sulfur has been perferentially mined. The ISGS estimates that about 37 percent of the coal resources with less than 2.5-percent sulfur are comparable to coal currently being mined in terms of seam thickness, depth, and some other parameters; these resources have been classified as having a high potential for development.

With the passage of the latest amendments to the Clean Air Act in November 1990, interest in relatively low-sulfur coal reserves has increased significantly, particularly in those reserves yielding coal with a sulfur content below 2.5 lbs $SO_2$/million Btu (equivalent to about 1.2- to 1.5-percent sulfur). Beginning

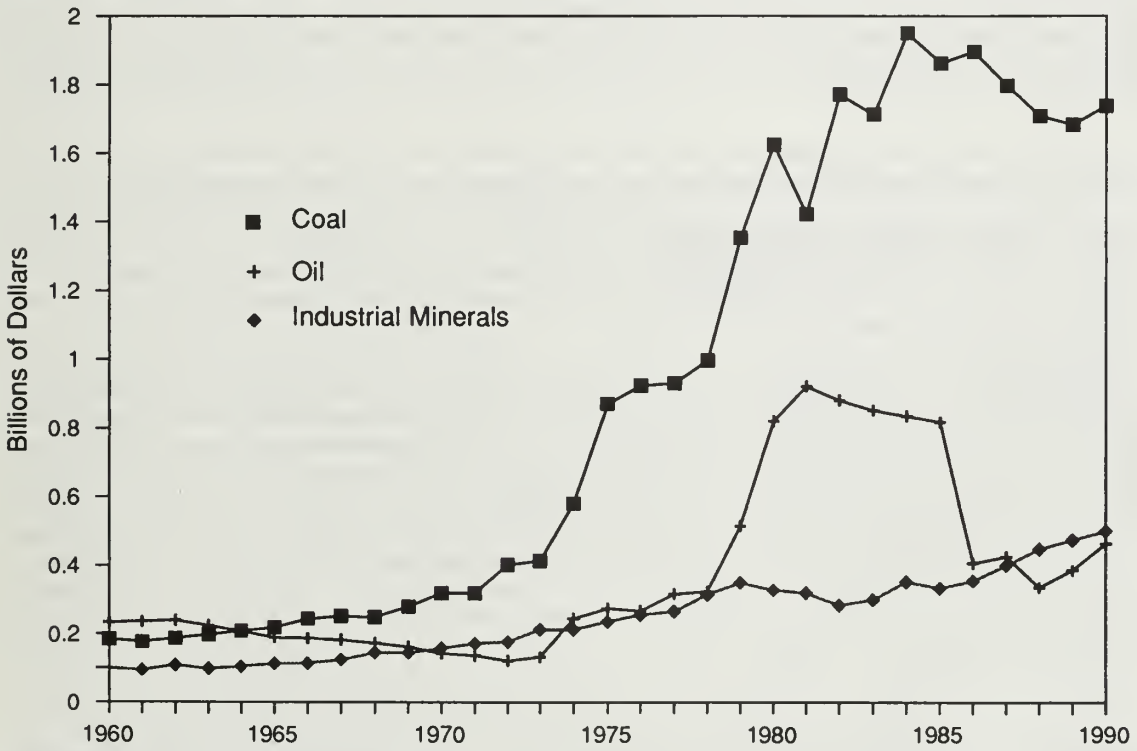



**Figure 1** Value of Illinois minerals and fuels.

Table 1 Mineral production data for 1989 compared to preliminary data for 1990[a]

| Minerals extracted | Unit | 1989 Quantity | 1989 Value ($1000) | 1990 Quantity | 1990 Value ($1000) | Percentage of change from 1989 to 1990 Quantity | Percentage of change from 1989 to 1990 Value |
|---|---|---|---|---|---|---|---|
| Fuels | | | | | | | |
| Coal | thousand tons | 60,131 | 1,693,892 | 61,656 | 1,738,702[b] | + 2.5 | + 2.6 |
| Crude oil | thousand bbl | 20,380 | 380,693 | 19,950[b] | 458,850[b] | - 2.1 | + 20.5 |
| Natural gas | thousand Mcf | 1,477 | 3,175 | 1,446[b] | 3,124[b] | - 2.1 | - 1.6 |
| Industrial and construction materials | | | | | | | |
| Stone[c] | thousand tons | 60,829 | 256,832 | 63,800 | 283,100 | + 4.9 | + 10.2 |
| Sand and gravel | thousand tons | 37,582 | 161,835 | 38,350 | 171,500 | + 2.0 | + 6.0 |
| Clay[d] | thousand tons | 142 | 641 | 599 | 2,516 | +321.8 | +292.5 |
| Metals, gemstones and other undisclosed[e] | | | 53,822 | | 41,235 | | - 23.4 |
| Total value of minerals extracted | | | $2,550,890 | | $2,699,027 | | + 5.8 |

[a]Source: U.S. Bureau of Mines and Illinois Department of Mines and Minerals.
[b]Estimated by Illinois State Geological Survey.
[c]Dimension stone included with values that cannot be disclosed.
[d]Excludes fuller's earth; included with values that cannot be disclosed.
[e]Includes fluorspar, tripoli, lead, zinc, silver, copper, barite, peat, gemstones, fuller's earth, and dimension stone for 1989 and 1990.

January 1, 1995, all utilities must meet the 2.5 lbs $SO_2$/million Btu limit. One way to meet the limit is to switch from high-sulfur to relatively low-sulfur Illinois coal. In 1990, seven mines had filed contracts with the Federal Energy Regulatory Commission (FERC) claiming to have coal with sulfur contents equivalent to 1.5 to 2.5 lbs $SO_2$/million Btu and indicating that they were capable of delivering coal that meets the interim standard (to January 1, 2000, when $SO_2$ emissions will be limited to 1.2 lbs $SO_2$/million Btu for all utilities). One of the seven mines has since closed; another is idle. According to the latest (1989) annual report of the Illinois Department of Mines and Minerals, the total production from the remaining five mines was 10.5 million tons. Not all of this production met the 2.5 limit, and none met the more stringent 1.2 lbs $SO_2$/million Btu limit that will go into effect in the year 2000 (and has been in effect for new utility plants since 1979).

The state's coal mining industry is apprehensive. Companies mining high-sulfur coal expect to experience even more difficulty marketing their product. Mine closures are being predicted.

To meet the $SO_2$ reduction requirements of the Clean Air Act, the ISGS is increasing its efforts to develop processes for removal of sulfur from coal and stack gases after combustion. Research is also focusing on removal of other undesirable elements from coal, including mineral matter, chlorine, and nitrogen-containing compounds.

A process to produce high-surface-area hydrated lime that significantly increases the effectiveness of dry sorbent injection processes for removal of sulfur dioxide from stack gas has been developed at the ISGS. For example, in pilot-scale tests with ISGS materials, up to 90-percent removal of $SO_2$ was obtained at the U.S. Environmental Protection Agency (USEPA) under furnace sorbent-injection conditions of approximately 2000° F; up to 65-percent $SO_2$ removal was obtained at Research-Cottrell under boiler economizer conditions at approximately 1000° F; and up to 85-percent $SO_2$ removal was obtained at Consolidation Coal Company (CONSOL) under duct injection/humidification conditions at approximately 300° F. For phase II, year 2000 compliance, approximately 75-percent $SO_2$ removal would be needed for a typical Illinois coal. The ISGS is pursuing patent protection to license the technology.

Work is also in progress on (1) chemical cleaning processes for the removal of organic sulfur from coal, (2) physical cleaning processes for the recovery of preparation plant fines, (3) pelletization to improve the marketability and burning characteristics of fine coal, (4) studies of burning characteristics to ensure that processed coal can be used in conventional boilers, and (5) studies to form oxidized char and carbon molecular sieve from Illinois coal to help control water and air pollution.

The new amendments to the federal Clean Air Act also include provisions to reduce emissions of airborne toxic substances that may pose a risk to human health or the environment. The USEPA must conduct a 3-year study of health risks specific to utility sources and then decide whether controls are needed for power plants. Mercury was singled out for special a USEPA study. The ISGS has studied the content of trace elements, including mercury, in coal. Additional ISGS studies may be warranted because of the renewed concern about the effects of potentially hazardous elements that may be released into the environment during coal combustion.

Monterey Coal Company announced an agreement with CIPS that in 1992 the company will begin delivering coal to CIPS from its relatively low-sulfur coal reserve adjacent to its No. 1 Mine, referred to as the Hornsby Low-Sulfur Coal Area by the ISGS (described in ISGS Circular 540 of 1987). Starting in 1995, Monterey will deliver coal from the low-sulfur coal reserve only. Monterey indicated that the company controls about 200 million tons of coal reserves with a sulfur content in the 1-percent range. Currently, Monterey supplies coal averaging about 3.5-percent sulfur to CIPS. Monterey plans to use the longwall mining method to recover the low-sulfur coal.

The Miracle Mine near Oakland in northeastern Coles County was officially closed after extended attempts to keep the mine open. The mine was located in a significant deposit of lower sulfur coal. The mine started production in January 1989, but stopped production in August of the same year after producing only about 12,000 tons of coal. The mine has been idle since. At one point the owner of the company expressed hope to mine about 1 million tons of coal per year for 20 years from this mine alone. He anticipated opening two additional mines to the north in the Hindsboro area of Douglas County in the same lower sulfur coal reserves.

Zeigler Coal Company announced that it will close its Murdock Mine in Douglas County later in 1991. The Murdock Mine, the oldest operating mine in Illinois, has been operating since 1946. It produced from lower sulfur coal reserves. Zeigler Coal Company acquired Old Ben Coal Company in September 1990. Peabody Coal Company closed its River King No. 1 underground mine in St. Clair County.

Zeigler Coal Company reopened the Old Ben No. 21 Mine in Franklin County; the mine had been idled by Old Ben earlier. Freeman-United Coal Mining Company reopened its Crown III mine in central Illinois after the company received a new contract from Archer Daniels Midland of Decatur. The mine had been idle for several years.

Missouri Public Service announced that it plans to switch from high-sulfur Illinois coal to low-sulfur western coal to comply with the new clean air regulations. This utility has been a major user of high-sulfur Illinois coal for many years.

**Coal Database Management**

**Coal Quality Database,** *Damberger, C. Treworgy, Harvey* "What is the sulfur content of coals sold by Illinois mines?" is a common question. Coal analyses are proprietary with the private companies, but the ISGS does have an extensive database of analyses of face-channel samples collected from many mines over the years. These are not samples of the cleaned product sold by the mine.

One of the best approximations to the amount of sulfur in Illinois coal was recently made available by the U.S. Department of Energy (USDOE) Information Administration, which keeps records of contracts signed between mining companies and public utilities. A magnetic tape of the data was obtained and transferred to the ISGS database; the data include, among other items, the sulfur and heating values from those contracts. Initial analysis of the records for 1990 showed that only one of the 1,320 contracts with Illinois mines were for coal that could meet the federal clean air standard of 1.2 lbs $SO_2$/million Btu; whereas 118 contracts (about 9 percent) were for coal that meets the current federal standard of 2.5 lbs $SO_2$/million Btu. The data showed that only 0.6 percent of the contracts were for coal with less than 1.5 lbs $SO_2$/million Btu. Later, the tonnages of coal included in these contracts will be studied.

Another agency within the USDOE has recently provided yet another magnetic tape of analytical data on tipple and delivered samples (marketed products) for the Illinois Basin. Most analyses relate to coal purchases by the federal government. This database provides information on the quality of many coal mines that have produced and delivered in the past.

**Management of Data on Illinois Coal (NCRDS),** *C. Treworgy, Coats, DeMaris, Frankie, Sroka* Work was completed on our FY90 grant from the U.S. Geological Survey to collect and compile quality and

stratigraphic data on Illinois coals. During this period stratigraphic data for more than 800 coal test holes were compiled and correlated. Twelve samples of coal from six mines were collected and analyzed. As in past years, these data were entered into ISGS computer databases on coal quality and stratigraphy as well as into the National Coal Resource Data System (NCRDS) of the U.S. Geological Survey (USGS). In April 1991, the ISGS was awarded a grant of $15,000 for another 1-year project to compile stratigraphic data on Illinois coals. This grant will enable us to continue building our database to support current and future service and research activities related to Illinois coal. During the current year, stratigraphic data from at least 300 drill holes will be compiled, correlated, entered into our computer database, and transferred to the NCRDS.

**Coal Stratigraphic Information System**, *C. Treworgy, Coats, others* Stratigraphic data on coal and coal-related strata from more than 10,000 drill holes were added to this database during the past year. These data were acquired from seven completed ISGS projects and encoded or reformatted for this database. The database now contains more than 30,000 stratigraphic descriptions of borings, outcrops, and mine exposures.

**Coal Mine Information System,** *C. Treworgy, Bargh, Coats* A prototype for a new directory of coal mines was developed and is undergoing internal review. The directory is designed to accompany the new series of 1:24,000-scale mine maps that will be available later this year. The directory documents the sources and limitations of information used to compile each mine outline and provides information for each mine on the thickness and depth of the seam mined, the production and ownership history of the mine, geologic problems encountered in mining, and locations of all known former openings to the mine (e.g. shafts, slopes, and drifts). The new map format depicts the extent of mined areas relative to surface features and is based on USGS 7.5-minute quadrangle maps. The maps and directory are designed to facilitate the consideration of subsidence issues in land use planning and development. Maps for four quadrangles were completed during this period, bringing the total number of quadrangles in this series to six.

Work began on updating the series of 1:100,000-scale county mine maps to show mining as of January 1991. Maps have been obtained from all active mines in the state and are being digitized into the computer database. Seven coal mine maps were prepared for the U.S. Bureau of Mines. They will be used for an inventory of assets in the Shawnee National Forest for Jackson, Saline, Pope, Johnson, Union, and Alexander Counties.

**Coal Exploration Records,** *Frankie* Coal exploration and development decreased slightly in 1990. Thirteen companies filed 674 Test Hole Record and Plugging Affidavits from 23 counties with the Illinois Department of Mines and Minerals, as compared to the 889 affidavits filed in 1989. During the 1980s, coal exploration increased from 1,300 drill holes in 1981 to a maximum of 3,800 in 1983, and then decreased to 637 in 1988. About 222 of the holes drilled in 1990 are far enough away from active mines to be classified as exploration holes. This is a slight increase from the 195 exploration holes drilled in 1989. Most of the drilling is developmental and located near active mines in southern Illinois. The four leading counties were Williamson, Logan, Randolph, and Macoupin, accounting for 496 of the wells.

### Coal Mining Geology

**Ground Stability in Partial Extraction Mining in the Herrin Coal**, *Damberger and DeMaris (ISGS); Chugh, Phillips, and Singh (SIU-C)* This ongoing cooperative study with the Department of Mining Engineering at SIU aims at characterizing ground conditions in underground coal mines. A primary goal is to improve the predictability of unstable roof and floor sequences in advance of mining. Substantial progress has been made on work in mines into the Springfield Coal, and a final report is being written. The project is supported by the Illinois Mine Subsidence Research Program.

**Strike-Slip Fault at Crown II,** *Nelson and DeMaris* A strike-slip fault mapped across this mine appears to be unrelated to previously known structural features in the area. Resolution of map details and clearer understanding of movements may be reported in a publication. Final mapping was completed in the fall of 1990; analysis is ongoing.

### Coal Resources

**Availability of Coal Resources in Illinois**, *C. Treworgy, Bargh, Coats* The purpose of this project is to identify how much of Illinois' coal resources are available for development—that is, are free of technical and legal restrictions to mining. Factors limiting the availability of coal are being identified and

evaluated through studies of sample areas located throughout the coal field. Evaluation of the first study area, the Middletown Quadrangle located just north of Springfield, was nearly completed during this period. Preliminary results indicate that less than 60 percent of the coal resources are available for mining and possibly less than 25 percent of the resources may actually be recoverable. Factors limiting the availability of coal in the study area include weak roof and floor rock, thin bedrock cover, unfavorable stripping ratios, thin coal, and surface features such as cemeteries and interstate highways. A final report on this area will be prepared during the next fiscal year.

**Cooperative Research on the Springfield Coal,** *C. Treworgy and Bargh* A map, "Features Associated with the Springfield Coal Bed," was compiled from data collected by the Illinois, Indiana, and Kentucky Geological Surveys. The map shows the three-state region underlain by the coal, including the outcrop of the coal, mines, channels, and faults. The map was produced by computer using the ISGS GIS mapping system and electrostatic color plotter. The map is currently undergoing review and modification by staff of the three State Surveys and will be available to the public by the end of 1991.

**Coal Resources of the Dekoven and Davis Coals in Southeastern Illinois,** *Jacobson* The Dekoven and Davis Coals have been mined for many years in southeastern Illinois, Indiana, and western Kentucky, but no systematic study of the resources and reserves in these coals had ever been conducted, except where the coals are exposed at the surface. This ongoing study will assess the potentially significant coal resources in these two coals in several counties of southeastern Illinois.

• **Part 1. Saline and Gallatin Counties** A manuscript with maps, sections, and tabulations has been completed and reviewed. It is now in the hands of the editors for production of a bulletin.

• **Part 2. White and Hamilton Counties** Another 300 drill hole records were added to the data file for this project. To date, more than 800 drill hole records have been analyzed for this study. The data entered cover about two-thirds of White County. About one-third of the county has yet to be entered into the database. Data were moved from the Prime computer to a Coal Section workstation, in preparation for the planned shutdown of the Prime. This move will require that all the programs to do the contour maps and coal resource tabulations be rewritten because of the switch to a different operating system.

**Coal Characterization**

**Spatial Distribution of Organic Sulfur in Selected Illinois Basin Coals,** *Harvey, Demir, Lowry* The SEM-EDX method is used to determine the organic sulfur content of selected spots within coal macerals. Detailed knowledge of the variability of organic sulfur will help engineers design improved processes to reduce sulfur in coal. The organic sulfur content of maceral particles proved to be more variable than previously thought. The variability is highest among the inertinite macerals in five coals tested. A manuscript on the subject was published in *Organic Geochemistry* during June 1991.

**Characterization of Organic Sulfur in Macerals and Chars,** *Harvey, Demir, Lowry, Hackley* The main objective of this 2-year CRSC-funded project has been to describe and evaluate the variation and distribution of organic sulfur within the macerals associated with pyrite in typical Illinois coals and in their charred products. An interim report of the first year's work was made part of the ISGS Open File Series (OFS 1991-3). During this second year, test results of the pyrite-rich fractions of eight coals showed an enrichment of organic sulfur. Some part of the observed enrichment may be the result of the formation of elemental sulfur that could have formed by oxidation of the pyrite during sample processing. Special analyses of the elemental sulfur content of selected samples are in progress to confirm this hypothesis.

The second main task is to evaluate the organic sulfur distribution within macerals that occur in each major layer of the Herrin seam at two sites; one site is located under a marine roof shale and the other one located under a roof that is transitional to a nonmarine shale. Although it was already known that total sulfur in whole-seam samples was high under the marine shale and relatively low under the transitional shale, the SEM-EDX results to date confirm that the organic sulfur content is enriched in each maceral group where the coal underlies a marine shale, and depleted in each group under the transitional shale. These results help in the geochemical interpretation of how organic sulfur in coal is formed. A final report on this project is being prepared.

**Behavior of Sulfur and Chlorine in Coal During Combustion and Its Effect on Boiler Corrosion,** *C.-L. Chou, Hackley, Ruch (ISGS); and W. P. Pan (Western Kentucky University)* A major goal of this new project is to elucidate the mechanism of chlorine-enhanced corrosion of utility boilers. The gaseous species of sulfur, nitrogen, and chlorine in combustion gases are identified in the laboratory using two

techniques: (1) temperature-programmed pyrolysis coupled with quadruple gas analysis (QGA), and (2) thermogravimetric analysis in conjunction with Fourier transform infrared spectrophotometry (TG-FTIR). Preliminary QGA experiments showed that hydrogen chloride appeared to be the only chlorine species identified in the gas phase. Recent TG-FTIR experiments on an Illinois coal identified carbon oxysulfide (COS) along with a number of other gaseous carbon and sulfur species in the combustion gas. The presence of gaseous carbon oxysulfide is of special interest because it may corrode utility boilers by reacting with iron to form iron monosulfide.

**New Insight into the Chlorine-Nitrogen Relation in Illinois Basin Coals,** *C.-L. Chou* Hand-picked pure vitrain samples from high-chlorine coal have low ash and sodium contents but a high chlorine content, indicating that most of the chlorine occurs in the organic matter, not in ash-forming minerals. How chlorine is bonded in the organic matter is not well understood. A possible explanation is that it occurs in the form of hydrochloride of pyridine base (a nitrogen functional group). To determine the relation between chlorine and nitrogen in the organic matter of coal in a suite of lithotype samples, the chlorine and nitrogen contents were normalized with organic carbon, so that the chlorine and nitrogen contents would not be affected by the amount of mineral matter in coal. Disregarding fusains that contain an appreciable amount of sodium chloride, a positive correlation exists between the chlorine and nitrogen contents in the lithotypes, which supports the interpretation that chlorine is held at nitrogen sites. A paper on this subject was presented at the North-Central Section meeting of Geological Society of America.

**Characterization of the Wettability of Illinois Coals by the Film Flotation Method**, *Khan and Baxter* Differences in hydrophobicity are used in fine coal-cleaning processes to separate the coal from accompanying mineral matter. Film flotation tests partition coal samples into lyophobic and lyophilic fractions based on differences in wettability. Such tests, developed at the University of California in Berkeley, can be used to determine the relative differences in the wettability of different coals.

Film flotation tests were completed on the 45×60-mesh fraction of coals from six mines in Illinois; Coal Bank Sample 101 was used as a reference. Samples from the same material were also floated in a 1-liter Denver Cell using standard froth flotation conditions with docecan and MIBC. The film flotation tests using pure distilled water (no alcohol) showed that the flotation behavior of different coals can be predicted and compared and that the degree of oxidation of different coal samples of the same origin can be estimated. There was no direct, linear correlation between the amount of materials settled and the amount of coal that may be recovered by flotation processes.

**Isotopic Characterization of Organic Sulfur in Different Fractions of Coal and Coal Macerals,** *Hackley, Cao, Palmer (SIU)* The two primary sources of organic sulfur in coal are original plant sulfur and secondary microbial sulfide sulfur. Many researchers have hypothesized that since there are two isotopically distinctive sources, the different organic sulfur compounds in coal may have different isotopic signatures, reflecting the two primary sources of sulfur. To explore this hypothesis, the ISGS acquired from SIU some samples that have been physically and chemically separated at relatively low temperatures into separate fractions containing different groupings of organo-sulfur compounds. The organic sulfur from each sample has been isolated and will soon be analyzed for the isotopic composition of the organic sulfur from the different fractions.

**Sulfur Isotope Geochemistry of the Herrin (No. 6) Coal,** *Hackley, DeMaris, Cao, Liu* In earlier ISGS studies, it was observed that the isotopic composition of the pyritic sulfur in the Herrin Coal beneath the Anvil Rock channel deposit was significantly more positive than that of the organic sulfur in the coal on either side of the channel. Determining whether this was a typical characteristic of coal beneath the channel required collecting several small core samples of coal from three sites beneath, at the edge, and away from the channel deposit in the Herrin coal seam of an underground mine in central Illinois. Chemical and isotopic analyses of the forms of sulfur have been completed on the samples collected. Apparently, the isotopic signature was established by pre-erosion lithology, i.e. the marine Anna Shale. The concentration of pyritic sulfur appears to be lower near and beneath the channel deposits, indicating that the original pyritic sulfur concentration may have been changed because of the presence of the channel. Additional samples have been prepared for analysis to determine whether similar trends in the concentration of pyritic sulfur beneath the channel deposits may be observed at other locations in the Herrin coal seam. Instrumental difficulties prevented completing the analyses during the reporting period.

### Coal Cleaning: Physical and Microbial

**Process Development for the Production of Coal/Sorbent Agglomerates,** *Rapp, Lytle, Hackley, Moran, Kohlenberger, Rostam-Abadi (ISGS); Berger (UIUC); Griggs (CERL)* This project is supported

by the Center for Research on Sulfur in Coal (CRSC) and the Construction Research Engineering Laboratory (CERL). To improve the marketability of fine coal, the ISGS is investigating pelletization of fine coal with calcium hydroxide, a sulfur-capturing sorbent, as a method to produce fuel pellets that can be easily transported and will burn at the sulfur emission levels required by the Clean Air Act. Modern mining methods generate a significant amount of fine coal, which has limited marketability because the material is difficult to transport and process. Each year in Illinois, this practice results in the disposal of up to 5 percent of the state's total coal production.

Carbonation, the reaction of calcium hydroxide with carbon dioxide to produce a cementitious matrix of calcium carbonate, is being investigated as a method to improve pellet quality and the economics of coal pelletization. Results indicate that carbonation improves pellet compressive and impact strength and attribution resistance, and it waterproofs the pellets. Small-scale combustion testing indicates that up to 80 percent of the sulfur in the pellets can be captured when the pellets are burned at 850°C, which is the operating temperature for many fluidized-bed combustors. In addition, tests done in stoker boilers by outside organizations indicate up to 50-percent sulfur capture is possible under these conditions.

**Fine Coal Flotation of Plant Waste: An In-Plant Comparison Column Versus Sub-A Cells,** *Ehrlinger, Rapp, Lytle, Kohlenberger, Khan* CRSC, Kerr-McGee Coal Corporation, and Deister Concentrator Company support this project to determine the usefulness of a flotation column for recovering the fine coal from Illinois coal preparation plants. A 30-inch-diameter by 35-foot-tall Deister Flotaire column flotation machine was erected at the plant of the Kerr-McGee Coal Corporation in Galatia, Illinois. It was designed to operate on a representative sample of the feed normally treated in the subaeration flotation cells used in the remainder of the plant. A series of 23 flotation tests varying in duration from 30 minutes to 14 hours was run. Concentrate grades on No. 6 Coal (Herrin), obtained with the Deister Flotaire cell, were 8.0-percent ash, 2.07-percent total sulfur, 0.71-percent pyritic sulfur, 1.37-percent organic sulfur, and 13,419 Btu/pound. An 83.5-percent recovery of the Btu values was obtained along with a rejection of 94.1 percent of the ash and 77.5 percent of the pyritic sulfur. Plant tests showed a higher ash (11.7 percent), a lower Btu grade and recovery (12,695 Btu and 79.3 percent) than the column. Similar results have been recorded while treating Illinois No. 5 (Springfield) Coal. The significant feature of the test program was the demonstration that the column can generate slightly better products than conventional flotation cells with an improved Btu recovery at a lower power consumption.

**Particle-Size Enlargement of Fine Coal or Char Using Lignocellulosic Residue from TVA's Biomass Program,** *Ehrlinger and DeBarr (ISGS); P. Chow (UIUC); R. Strickland (TVA)* Supported by the Tennessee Valley Authority (TVA) and conducted in cooperation of the Forestry Department at the University of Illinois at Urbana-Champaign, this project is investigating the enlargement of fine coal particles produced during preparation of Illinois coal and a concomitant decrease in the sulfur content by adding a low-sulfur lignocellulosic residue. The first period's work utilized fine coal from CRSC-sponsored flotation programs and lignins from TVA's hardwood forest harvest; the second period's work substituted lignins from municipal waste (largely newsprint); and the current period utilized lignins made by TVA from Illinois corn cobs and corn stover (husks and stalks). The results of the ongoing work with TVA have resulted in the ISGS forming a series of pellets using fine Illinois coal (from flotation processes) and lignins from trees, municipal waste, corn stover, and corn cobs. The pellets are a stoker-type feed, high in energy value, low in ash and sulfur values, and easy to handle. There seems to be little difference in the products made from either the hardwood, the municipal waste or the corn stover; however, products utilizing corn cobs are not bound as well.

**Wet-Grinding and Selective Flocculation to Reduce Ash, Sulfur, and Chlorine Contents in Coal,** *C.-L. Chou and Woodward* This CRSC project developed a physical cleaning process, based upon wet-grinding and selective flocculation, to remove chlorine, pyrite, and other ash-forming minerals from coal. Chlorine was leached from the coal by using wet ultrafine grinding and was separated together with liberated pyrite and other ash-forming minerals by using selective flocculation. Dosages of dispersants and flocculants were determined to obtain acceptable cleaning and Btu recovery. Up to 74-percent chlorine reduction was achieved with approximately 50-percent ash and pyrite reduction and 90-percent Btu recovery for a high-chlorine coal sample (IBC-109 of the Illinois Basin Coal Sample Program). The results showed that the removal of chlorine along with sulfur from coal is feasible. The project was completed in August 1990, and the final report will be published as Open File Series 1991-9.

**Microbial Pyrite Suppression from Illinois Coals: Microbiology and Chemistry,** *Risatti* This year completes the fourth and final year of a joint effort by the ISGS and Northwestern University. Earlier work on this project indicated that some bacteria produce compounds that improve pyrite separation from coal

during froth flotation processes by "wetting" the pyrite surfaces. ISGS tasks for this year were to isolate and if possible, identify these bacterial metabolites with the aim of using them to enhance the physical desulfurization of Illinois coals. Using column chromatography, we fractionated the proteins in the bacterial supernatant with preparatory isoelectric electrophoresis and further purified the active fractions according to their isoelectric values. These fractions were then sent to the Northwestern group who have characterized the suppression activity of the fractions by induction time assays. These data are reported in the final report, which was submitted to the granting agency on June 30, 1991.

### Coal Cleaning: Chemical and Thermal

**Dissolution of Sulfur from Coal by Solvent Extraction,** *M.-I. M. Chou, Lytle, Ruch, Chaven, Hackley, Hughes, Harvey, Frost (ISGS); Buchanan (EIU); Stucki (UIUC); Huffman and Huggins (University of Kentucky)* The extractability of the organic sulfur, including elemental sulfur, from high-sulfur Illinois coal is being determined. Understanding the mechanism and kinetics of sulfur extraction could be essential to both basic and applied coal desulfurization research.

Various solvents including benzene, methanol, trichloroethylene, and tetrachloroethylene (PCE) have been tested on sulfur extraction from IBC-102 coal. Preliminary results indicate that, under the most favorable condition, all the solvents removed most of the elemental sulfur, but only small amounts of organic sulfur. A proposal, "Sulfur Removal from High-Sulfur Illinois Coals by Low-Temperature Tetrachloroethylene (PCE) Extraction," was submitted to the Center for Research on Sulfur in Coal. In this 2-year study, a PCE desulfurization process reported by the Midwest Ore Processing Company will be applied to an Illinois coal for two purposes: (1) to verify certain hypotheses concerning errors on using ASTM analysis as a "forms-of-sulfur" determination method for the PCE process evaluation, and (2) to determine the possibility of improving the organic-sulfur removal from high-sulfur Illinois coals using the adopted PCE desulfurization process, which has been reported to be successful in removing organic sulfur from other coals.

**Desulfurization of Illinois Coal Using Ethanol,** *Wu, Shiley, Bhagwat, Dickerson, Brewer, Adomaitis, Donnals, Goheen, Joshi* The three-step and one-step ethanol coal desulfurization processes were compared head-to-head in a project that began in September 1990. Funding was supplied by the Challenge Fund of the Illinois Department of Commerce and Community Affairs, the Illinois Corn Marketing Board, the Ohio Corn Growers Association, and the USDOE cost-share funds available through the University of North Dakota Energy and Environmental Research Center (UNDEERC).

Tests conducted on the three-Step process at the UNDEERC achieved a 40-percent sulfur reduction at the 2-kg/hour continuous-feed scale. It did not appear that the ethanol step resulted in much additional reduction in sulfur content (total or organic). Either the reactive troilite catalyst was not successfully produced or the low pressure used (450kPa) did not allow the ethanol to adequately penetrate the coal. In addition, the available data do not indicate that a single fluidized-bed reaction system can effectively prevent back-reactions due to the rapid heat-up inherent in such a system. A multiple-staged fluid-bed system may be more effective.

During the later half of FY91, the project focused its efforts on the one-step process, in which ground coal is heated and treated with ethanol in the presence of a reaction accelerator. This patented process removes both the organic and the mineral sulfur in a single step. At Ohio University, one-step batch laboratory results at the 60-g scale have achieved total sulfur reductions as high as 96 percent. Researchers at the ISGS and UNDEERC have not been successful in their attempts to confirm these data. The results have typically been:

| Temperature | Range of Sulfur Reduction | Average Sulfur Reduction |
|---|---|---|
| 470° C | 28% - 63% | 44% |
| 400° C | 16% - 33% | 20% |

### Coal Combustion

**Development and Evaluation of High-Surface-Area Hydrated Lime for $SO_2$ Control,** *Rostam-Abadi, Moran, Lordgooei, Lytle, Eidel, Kruse, Cooper* Since 1986, the ISGS has been developing a process to produce high-surface-area (HSA) hydrated lime with far more activity for adsorbing $SO_2$ than commercially available hydrated lime. The process has been optimized in batch, bench-scale reactors. For example, in pilot-scale tests with ISGS materials, up to 90-percent $SO_2$ removal was obtained at U.S. Environmental Protection Agency (USEPA) under furnace sorbent injection conditions of approximately 2000° F; up to 65-percent $SO_2$ removal was obtained at Research-Cottrell under boiler

economizer conditions at approximately 1000° F; and up to 85-percent $SO_2$ removal was obtained at Consolidation Coal Company (CONSOL) under duct injection/humidification conditions at approximately 300° F. The removal results, almost twice as much as the best-performing commercial hydrates, are sufficient to bring Illinois coals into compliance with acid rain legislation goals for the year 2001 (1.2 lb $SO_2$/million Btu). The projected cost of the ISGS high-surface-area hydrated lime is about the same as the cost of currently available commercial hydrated lime. A patent covering the process has been applied for in the United States, Canada, Japan, Australia, and Europe. Research Corporation Technologies, a marketing and licensing organization, has accepted the responsibility for patent prosecution, marketing, and licensing of the ISGS invention. Dravo Lime Company agreed to support the project as an industrial partner and is neogtiating with Resource Corporation Technologies (RCT), who is seeking to license and commercialize the process as approved by the Board of Natural Resources and Conservation last year.

The ISGS received funds from the ICDB through the CRSC and a Governor's Challenge Grant through DCCA to design, build, and operate an integrated, continuous lime-hydration process optimization unit (POU) capable of producing 20 to 100 pounds of hydrate per hour. The POU has been designed and built. Seven shakedown tests, requiring a total of 40 hours of operation, were successfully performed with the hydration reactor. More than 500 pounds of products have resulted. The products from one of the tests were characterized and were comparable to products prepared from the same lime in the smaller batch hydrator. Scale-up and continuous operation do not appear to adversely affect the quality of the hydrated lime. During FY92, the POU will be used to generate design, construction, and operation data necessary for the private sector to scale-up the process to a commercial level.

**Combustion Characteristics of Coal-Char Blend Fuels,** *Debarr and Rostam-Abadi* The reduction in volatile matter (VM) that accompanies most thermal and chemical coal-desulfurization processes influences combustion characteristics such as ignition temperature, flame stability, and carbon burnout. To improve combustion efficiencies when firing low-VM chars may require auxiliary fuel, which may be supplied by blending the chars with coal. The goal of this research funded by the ICDB through CRSC and in part by USDOE through the University of North Dakota Energy and Environmental Research Center, is to supply a broad range of combustion characterization data on low-VM chars and fuels prepared by blending the chars and parent coal.

Combustion efficiencies and ash-deposition behaviors of three chars (9, 14, and 18-percent VM) and coal-char blends (25 and 35-percent VM) were studied. The chars were prepared under mild gasification conditions from an Illinois coal. Combustion tests were performed in an entrained flow reactor under conditions representative of coal-fired boilers (1300° C, 3-percent oxygen, 0.8 seconds residence time). Results suggest that the most effective way to achieve an acceptable level of combustion efficiency for chars is to increase the VM content to 25 to 30 percent by blending with coal and using slightly higher oxygen concentrations (4 to 5 percent). At 3-percent oxygen, coal and char fractions of the blends appear to burn independently, suggesting a form of staged combustion. This could have direct implications in reducing $NO_x$ formation during combustion. Ash deposits of coal and coal-char blends grew at the same rate and exhibited similar strengths under the conditions tested.

**Modification of High-Temperature Combustion System,** *Hackley and Cao* Sulfur yields were low when a second combustion zone, consisting of CuO was used on an ISGS high-temperature combustion system. Industrial conditions are simulated by sliding the coal samples into the hot zone of the high-temperature furnace very quickly and burning them in an atmosphere of air. Volatiles are released very rapidly and do not completely combust in the hot zone; therefore a second combustion zone, consisting of CuO, is used. Several experiments have been run to determine why sulfur yields have been low. Apparently, the major problem is condensation of sulfur on the inside of the ceramic tube just beyond the CuO zone. The system has been modified in such a way as to minimize condensation on the ceramic combustion tube. Yields of sulfur have significantly improved, which will result in better mass balance calculations for combustion experiments.

### Fuels and Chemicals from Coal

**Lignin-Augmented Bituminous Coal Depolymerization: A Route to Clean Fuels,** *Kruse, Feizoulof, Ehrlinger; Knudson (University of North Dakota Energy and Environmental Research Center [UNDEERC]); Assanis (UIUC); Porter (Western Research Institute [WRI]); Bourke and Uzkan (General Motors [GM]); Strickland (Tennessee Valley Authority, [TVA])* CRSC, GM, TVA, and USDOE (through UNDEERC) support this work. Low-ash, coal-like solids are produced from Illinois coals by the ChemCoal process. The process uses a phenolic solvent, aqueous sodium ions, and carbon monoxide (340° to 350° C, 1800 to 2000 psig) to solubilize (lightly depolymerize) coal. Undissolved ash is removed

by centrifugation before precipitation of the clean ChemCoal solids by alcohol. Western low-rank coals have sufficient phenolic precursors to produce recycle solvent. Higher rank Illinois coals do not. Current ISGS work seeks to compensate for the deficiency in Illinois coals by adding lignin to the reaction mix.

ChemCoal solids (0.2 to 0.3 wt% ash and 0.6 wt% sulfur) were obtained in 60 to 70 wt% yield from Herrin (Illinois No. 6) Coal (IBC-109) and a lignin byproduct of TVA's alcohol-from-wood process. Essentially all the pyritic sulfur and about 10 percent of the organic sulfur were removed. Allison Gas Turbine Division of GM commends the properties of ChemCoal solids for use in gas turbines. GM's electromotive division has used ignition delay and combustion rates provided for the ISGS by the Morgantown Energy Technology Center to predict performance in a diesel engine. ISGS ChemCoal solids have been size-reduced for the engine tests in Amoco Research Center's fluid energy. A fully instrumented and calibrated two-cylinder Lister-Petter engine is available in the UIUC Automotive Systems Laboratory to confirm GM's predictions. A proposal to continue this research has been submitted to CRSC.

**Upgrading Mild Gasification Char: Evaluation of Oxidized Char as a Catalyst**, *Kruse, Lytle, Rostam-Abadi, Chou, Feizoulof (ISGS); Fatemi, Mahoney, Beaulieu, Schreiner, Zajac (Amoco Research Center [ARC]), Naperville, Illinois)* This research, supported by CRSC and USDOE, was initiated to exploit properties of oxidized char disclosed in three patents issued to the principal investigator and coworkers in the 1960s. The goal is to determine how effective oxidized char will be for adsorbing undesired organic compounds and then destroying them when the temperature is elevated to a range where the oxidized carbon is known to transform some objectionable organics into readily managed compounds. Oxidized char is an excellent dehydrohalogenation catalyst.

A moderately high-surface-area char (500 $m^2/g$) was produced by steam gasification of mild gasification char, and it has been successfully converted to a catalytic variety by oxidation in a fluidized-bed reactor. This catalyst has now been shown to be effective in transforming various classes of chemicals into hydrocarbons and smaller compounds that are eliminated. Sufficient catalyst was produced to begin the applications testing at Amoco Research Center (ARC) while continuing refinement of the production method at the ISGS. Amoco Research Center (ARC) has shown that the oxidized activated char is effective in adsorbing a wide range of compounds of concern by the U.S. Environmental Protection Agency. Atomic binding energies of surface elements suggest that not only oxygen but also nitrogen may be involved in the active sites.

**Production of Carbon Molecular Sieves from Illinois Coals,** *Lizzio and Rostam-Abadi* Commercial interest in carbon molecular sieves (CMS) is growing and these materials have become an important class of carbonaceous adsorbents for application in the separation of small gas molecules, e.g., oxygen and nitrogen in air. The overall objective of this 2-year project, funded by the ICDB through the CRSC, is to ascertain whether Illinois coals are suitable feedstocks for the production of CMS and to evaluate the potential application of these products in gas separation processes. The data generated in this study should provide information to help design and engineer CMS with a proper pore size that could help resolve a specific gas separation/purification problem.

Chars were prepared from an Illinois coal under a wide variety of pyrolysis and activation conditions. Coal chars having commercially significant surface areas of 1500 to 2100 $m^2/g$, total pore and micropore volumes of 0.80 and 0.60 $cm^3/g$, respectively, and a micropore size distribution centered at 6 to 10Å were produced using special additives and heat-treatment conditions. These high-surface-area chars have more than twice the surface area of conventional carbon and zeolite molecular sieves. Carbon deposition, using methane as the cracking gas, was shown to be a useful technique to modify the gaseous adsorption properties of the high-surface-area char. Modifying its pore structure to achieve a desired molecular sieving behavior and developing experimental techniques to characterize its molecular sieve properties will be the emphasis of next year's activities.

### Liquids and Gases from Coal

**Premium Mild Gasification Liquid: Char and/or Tar Recycle and/or Lime Additive,** *Williams and Kruse* The goal of this research was to produce premium coal-derived liquids by a modified mild gasification approach. The modifications evaluated were doping of coal with lime, addition of a heavy tar fraction, and addition of catalytically active oxidized char.

The effects of increased lime-to-coal ratio of the lime-doped samples on the moisture- and ash-free (maf) char, oil, and gas yields were small. Increased lime-to-coal ratios resulted in greatly reduced evolution

of hydrogen sulfide and carbon dioxide. The combustion efficiency of the feed and char product generally increased as the lime-to-coal ratio increased. Increased lime-to-coal ratios resulted in improved oil API gravity, viscosity, and boiling characteristics.

Mild gasification experiments were conducted with the addition of heavy tar fractions to coal. Comparing the tar-to-coal ratios of 0, 0.05, 0.15, and 0.25, the highest to lowest quality oils were produced in the following order: 0.05, 0, 0.15, and 0.25. The char yield decreased and the oil yield increased as the tar-to-coal ratio increased. The data indicate that recycling the heavy tar would increase the light oil yield and eliminate the heavy tar upgrading expense.

Improvements in oil yield or quality did not result under mild gasification conditions tested with the addition of catalytically active oxidized char to the coal.

**Technical Support Services**

**Illinois Basin Coal Sample Program,** *Kruse, Chaven, Ehrlinger, Gavrilovic (ISGS); Vorres (Argonne National Laboratory)* The Illinois Basin Coal Sample Program (IBCSP), established in 1983, facilitates data comparisons among laboratories conducting research on Illinois Basin coal. The ISGS and the CRSC are closely linked to meet the goal of the Illinois Department of Energy and Natural Resources (ENR) of promoting quality research on Illinois coal both in-state and out-of-state. The nine lots of coal from which samples are delivered to requesters worldwide were selected primarily to meet the needs of coal research projects funded through the CRSC. Indiana joined the program in 1986 by providing funds through its Energy Development Board for a multi-ton lot (IBC-106) of coal collected from the Indiana V seam. This coal is equivalent to the Illinois Springfield (No. 5). Indiana will support resupplying IBC-106 and adding an additional lot.

Eight of the nine lots are maintained in a nitrogen atmosphere. The remaining lot is a pristine, prepackaged coal that matches the Herrin (Illinois No. 6) Coal in the Argonne Premium Coal Sample program. The availability of this coal from both programs contributes to making Illinois No. 6 the most popular selection nationwide and perhaps worldwide for coal research. The availability of well-characterized Illinois coals has leveraged a modest Illinois investment in a "Coal Bank" into valuable information about Illinois coals funded by other states, the federal government, and private industry.

**Coal Analysis Laboratory Service**

Coal Analysis Laboratory staff are responsible for record keeping, maintenance, and distribution of samples from the Illinois Basin Coal Sample Program to requestors. There were approximately 55 requests for 126 samples of IBC coal this year.

About 272 samples involving approximately 1,300 individual chemical analyses and 129 particle-size determinations were performed during this report period. The Coal Analysis Laboratory has successfully completed the task of reinstating the ASTM test for the Equilibrium Moisture or moisture-holding capacity of coal. The service is now online and available for coal geologists to use for ranking studies.

About 50 samples of coal and char were batch-extracted with perchloroethylene (PCE) for the determination of elemental sulfur by liquid chromatography. Acid treatment of char for the determination of volatile sulfide seems to indicate no evidence of formation of elemental sulfur as one of the intermediates of sulfur byproducts.

Following the development of and scale-up step in the ISGS high-surface-area hydrated lime project, the Coal Laboratory has successfully determined the particle-size distribution of high-surface-area hydrated lime in alcohol using the Microtrac II analyzer.

A method for direct determination of pyritic sulfur and/or elemental sulfur in coal, employing Chromous chloride ($CrCl_2$) reduction, is being developed and tested for precision, sensitivity, and accuracy. This method can be useful for direct determination of pyritic sulfur in milligram sample sizes and is an alternative method for the currently used ASTM procedure that involves the determination of iron in nitric acid extraction.

The laboratory also continues monthly participation in two national round-robins and biannually in one international program for quality assurance and quality control (QA/QC) purpose. Internal control samples are routinely used in all analyses for Coal Laboratory QA/QC.

**Low-Temperature Ashing Laboratory Service,** *Lowry* Forty samples were ashed and 61 were etched in the ashing laboratory to assist in more than eight different projects.

**SEM Laboratory Service,** *Lowry and Harvey* Complaints to the manufacturer about the poor resolution and operation of the scanning electron microscope (SEM) resulted in their taking the instrument back to the factory to rebuild it and give it operating specifications equivalent to their new instruments. New computer boards and key hardware parts were installed. The repair and reinstallation at the ISGS took 3 months and seriously delayed research on several projects. Nonetheless, the instrument has since given excellent resolution and consistent operations are now achieved. Work on two projects, Regional Petrographic Study of the Aux Vases Sandstone and Characterization of Organic Sulfur in Macerals and Chars, have been the main activities in the laboratory in recent months. For the year, the SEM was used on 111 occasions by four ISGS operators for approximately 450 hours of microscope operation. This laboratory is jointly supported by the ISGS and the Illinois Natural History Survey.

**Technology Transfer and Information Services**

**Information on Coal Mining Geology and Subsidence,** *DeMaris, Frankie, Bargh, Damberger, C. Treworgy* The ISGS provides information for internal and external requestors in the areas of historical mining, mine maps, coal resources, potential for mine subsidence, and mining problems. The ISGS also assists visitors in collecting coal or coal-related samples as well as maintaining internal records on coal, coal mines, and coal production. The ISGS responded to more than 100 requests last year.

A major earthquake forecast for December 1990 prompted many calls and letters asking for information, including copies of mine maps. Individuals, school administrators and teachers, government agencies, and construction firms were concerned about the potential of collapse of old underground mine workings during an earthquake. The Bloomington-Pantograph published a report on underground mines in the Bloomington-Normal area and the possibility of collapse of old mine workings during an earthquake. The report was partly based on a lengthy interview of Dr. Damberger by the paper's reporter. An increasing number of requests are now received from engineering and consulting firms engaged in construction or in landfill siting projects in undermined areas. ISGS has developed a 2-page letter report showing the greatly reduced movements at the depths of the mines during an earthquake. The ISGS Coal Section maintains maps showing undermined areas and has a library of coal mine maps on microfilm.

**General Information on Illinois Coal,** *Damberger and Coal Section staff* Staff responded to many requests for information about about Illinois coal; for example, the administrator of a school district in southern Illinois was uncertain about the meaning of terms used in the characterization of coal quality. He is in a better position to compare bids now that he has acquired coal-related information. During discussions in the Illinois legislature, and within the coal mining and utility industries, the question came up of how much coal meeting the interim emission standard of 2.5 lbs $SO_2$/million Btu is available in Illinois. The ISGS provided information to several groups and submitted a memo to ENR on the subject.

The National Academy of Sciences Research Council considered the establishment of a working committee on the availability of coal resources in the nation and invited coal resource experts from around the nation to discuss the need for such a study by a NRC committee. Dr. Damberger, Head of the Coal Section, attended the meeting. Dr. Damberger continues to serve on a Steering Committee of USDOE's Energy Information Administration (DOE/EIA) on the Assessment of the U.S. Coal Resources. He advises DOE/EIA on how to structure the major reevaluation of its coal reserve database.

**Mined-Out Areas, Urban Lands, and Population Density,** *C. Treworgy and Hindman* The proximities of coal mines and other underground mines to urban areas were evaluated in this project (completed in 1989). For each Illinois county that has had some underground mining, tables and maps were prepared showing acreages of urban land and number of housing units that may be exposed to risk of subsidence. During the report period, a summary of the findings of this project was published by the ISGS with support from the Illinois Mine Subsidence Insurance Fund (EG 138, *The Proximity of Underground Mines to Residential and Other Built-up Areas in Illinois*). The full project report is on open file.

**Notes on the Determination of ASTM Coal Rank,** *Harvey in cooperation with A. P. Hoeft (Consultant) and J. A. Luppens (Phillips Coal Company)* An accurate classification of coals by rank according to the American Society for Testing and Materials (ASTM) is important to many producers, utilities, and taxing agencies. Harvey, chairman of the ASTM Subcommittee on Classification of Coals, supervised a major revision in the ASTM standard on Classification of Coals by Rank; it was recently approved by the Society. A paper on the topic was submitted to a scientific journal.

Harvey, assisted by the ASTM subcommittee, sent the USDOE Office of Fossil Energy a list of recommendations for the U.S delegation to the United Nations ECE Committee on Coal regarding their newly proposed scheme to rank and classify coals throughout the world. The recommendations were supported by the main ASTM Committee on Coal and Coke, and they were well received by the delegation.

## OIL AND GAS

In response to the needs to increase oil recovery from discovered fields and to aid economic development of the depressed Illinois oil industry, the ISGS has expanded its program of research and service in oil and gas resources. Its goals are to aid Illinois' independent oil producers in the recovery of higher percentages of oil from fields already discovered, develop new incentives to encourage exploration, promote wise development of Illinois' oil and gas resources, and provide complete and timely information to the oil industry.

The first results of the Improved and Enhanced Oil Recovery Program, jointly supported by the Illinois Department of Energy and Natural Resources and the U.S. Department of Energy, have been published. More are forthcoming, signaling increased technology transfer. The ISGS has been a national leader in demonstrating to the USDOE and industry that an understanding of reservoir architecture and heterogeneity is required to effectively design and utilize engineering practices to increase production.

### Oil and Gas Program for Illinois

To recover higher percentages of oil from Illinois' petroleum-producing reservoirs, it is necessary to increase understanding of the nature of the reservoirs by acquiring knowledge that will help prolong and enhance productivity. The oil and gas geosciences research program has several significant goals:

- define the state's remaining unrecovered mobile oil (currently estimated at 1.4 billion barrels);
- transfer results of otherwise unobtainable research to the Illinois independent oil producers;
- persuade stripper well operators not to abandon access to remaining oil in place;
- develop technology to enhance production from mature fields;
- prove that future reserve additions in Illinois can come from extensions to existing fields and intensive directed development of existing fields through geologically targeted infill drilling;
- encourage renewed hydrocarbon exploration in the Illinois Basin.

The ISGS Oil and Gas program aims to aid the petroleum industry in exploration and development of Illinois resources by providing the comprehensive data collection, mapping, and subsurface stratigraphic research on possible petroleum targets and new techniques for exploiting existing fields and plays. Oil and gas data are made available to the public via (1) an annual report on the petroleum industry in Illinois; (2) a monthly drilling report; (3) Oil and Gas Development Maps; (4) Oil and Gas Pay Maps (showing the geographical area underlain by oil production from individual rock layers); (5) maps showing the subsurface depths of selected strata; (6) special publications; and (7) the Geological Records Unit, which contains more than 331,000 files, including data from more than 140,000 oil and/or gas tests.

### Oil and Gas Statistics

**Annual Statistics and Records,** *Huff and Liu* Geological records, including well logs, are submitted to the ISGS from wells drilled each year by industry in accordance with state laws and regulations.

**Number of holes reported in 1989, compared to 1990**

| | *1989* | *1990* |
|---|---|---|
| Oil and gas tests | | |
| New holes | 986 | 1,201 |
| Old holes drilled deeper | NP | NP |
| Service wells | | |
| New holes | 118 | 160 |
| Old holes drilled deeper | NP | NP |
| Structure tests | 0 | 1 |

NP = none processed

The 1,201 new holes reported in 1990 included 488 oil wells, 62 gas wells, and 651 dry holes. In 1990, Illinois ranked fifteenth in the United States in oil production; annual production (fig. 2) fell to 19,954,000 barrels, 2.1 percent less than in 1989 and its lowest total in more than 50 years. Discoveries reported included nine new pay zones in existing fields, and 19 extensions to fields.

**Illinois production in 1990, compared to 1989 (MB = 1000 barrels)**

| | *1989 MB/month* | *1990 MB/month* | *% change from 1989* |
|---|---|---|---|
| January | 1,861 | 1,849 | -0.6 |
| February | 1,505 | 1,578 | +4.8 |
| March | 1,752 | 1,737 | -0.8 |
| April | 1,638 | 1,595 | -2.6 |
| May | 1,768 | 1,628 | -7.9 |
| June | 1,706 | 1,569 | -8.0 |
| July | 1,749 | 1,761 | +0.7 |
| August | 1,782 | 1,760 | -1.2 |
| September | 1,702 | 1,623 | -4.6 |
| October | 1,757 | 1,711 | -2.6 |
| November | 1,708 | 1,682 | -1.5 |
| December | 1,453 | 1,461 | -0.5 |

### Improved Oil Recovery Methods and Concepts

The Improved and Enhanced Oil Recovery Program by Reservoir Characterization, jointly supported by the Illinois Department of Energy and Natural Resources (ENR) and the U.S. Department of Energy (USDOE), is in its third year. This $4.9 million, 4-year effort is aimed at providing information to maximize hydrocarbon recovery from Illinois reservoirs. USDOE estimates place Illinois ninth among the states with 1.5 billion barrels of mobile, bypassed oil. This oil remains in the reservoir after normal production. The project is providing information on hydrocarbon resources, reservoir characterization, and methods that will improve mobile hydrocarbon extraction. The transfer of technology to industry and the general public is a significant component of the program. The following field and project reports highlight progress on the USDOE/ENR program, which focuses on the Cypress and Aux Vases sandstones—two of Illinois' most prolific oil-bearing strata.

Fifteen reservoir studies were in progress this past year:

**Reservoir Studies**

| *Cypress Sandstone reservoir location* | | *Aux Vases Sandstone reservoir location* | |
|---|---|---|---|
| *Field* | *County* | *Field* | *County* |
| Bartelso | Clinton | Boyd | Jefferson |
| Lawrence | Lawrence | Dale Consolidated | Hamilton |
| Mattoon | Coles | Energy | Williamson |
| Parkersburg | Richland, Edwards | King | Jefferson |
| Richview | Washington | Mattoon | Coles |
| Tamaroa | Perry | Oakdale, Markham City N | Jefferson |
| Xenia East | Clay | Stewardson | Shelby |
| | | Zeigler | Franklin |

- **Bartelso Field,** *Whitaker and Finley* The study details stratigraphic and structural factors that affect hydrocarbon reservoir development and hydrocarbon recovery from sandstones of the Cypress Formation. The Cypress at Bartelso has been subdivided into four separate sandstone intervals, the upper three of which contain oil and gas. Each Cypress reservoir in the field is described in detail to help establish the optimal methods to use for hydrocarbon extraction. At the time of this report, the draft report on Bartelso Field is in peer review.

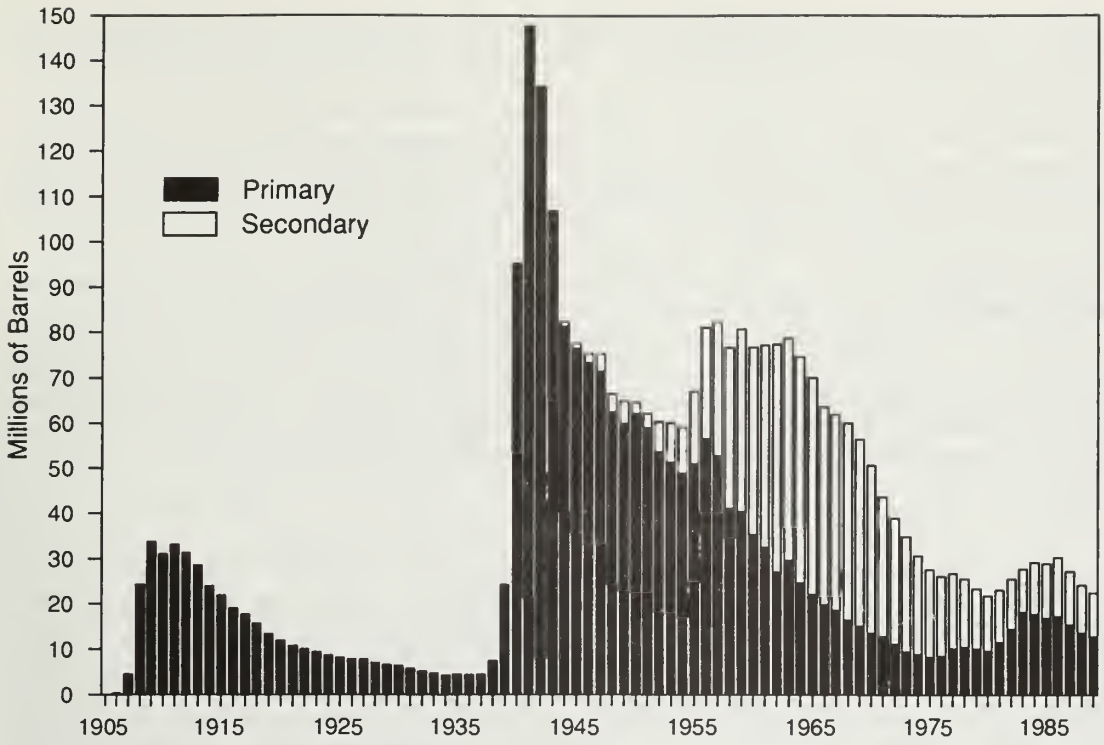



**Figure 2** Yearly production of oil in Illinois (millions of barrels).

- **Boyd Field,** *Leetaru* Numerous cross sections, isopach, and structure maps of the Boyd Field have been completed. The sand isopach map, combined with preliminary thin section analysis, suggests that the Aux Vases reservoir at Boyd Field is similar to the depositional environment at King Field (see below).

- **Dale Consolidated Field (Cantrell Unit),** *Beaty and Fagan* The Cantrell Unit in southwest Dale Consolidated Field is a stratigraphic oil accumulation with production from the Aux Vases Sandstone. Reservoir sands, trending southwest-northeast, are marine bars typically 25 to 35 feet thick in the most prolific wells. Maps and cross sections are being prepared to further define sandstone geometries. A flow-unit fence diagram has been constructed to delineate lateral and vertical heterogeneity to interpret locations of potentially bypassed mobile oil. A production history analysis is almost complete and waterflood maps are being prepared to aid in the determination of reservoir sweep efficiency. Petrographic studies are being used to help determine cements and clays that may affect hydrocarbon recovery.

- **Energy Field,** *Huff* The Energy Field produces only from Aux Vases Sandstone, is moderately complex in geometry and lithology, and was the target of a promising but unsuccessful waterflood project. Recent development of the field has revealed primary production problems in the Aux Vases. Core from the field that has been and will be provided to the ISGS may give insights into the cause, prevention, and remedy of formation damage. Early SEM work shows that sand grains in the reservoir rock are coated with chlorite and illite clay minerals and have the potential to react with mud cleaning acid (MCA) and cause formation damage.

- **King Field,** *Leetaru Reservoir Heterogeneity and Improved Oil Recovery of the Aux Vases (Mississippian) Formation at King Field, Jefferson County, Illinois* (Illinois Petroleum 135) has been released to industry and the public. Most wells in this field were plugged and abandoned after a steady decline in production since 1966 and the collapse of oil prices in 1986. Premature abandonment of the field is forewarned by the recent detailed geological study. The facies mosaic formed by the mixed carbonate and siliciclastic, nearshore, shallow marine system has produced a high degree of reservoir heterogeneity. The compartmentalization of the reservoir has allowed large areas of the Aux Vases reservoir at King Field to remain unswept by waterflood projects. An estimated 1 to 2 million barrels of additional oil may be recoverable by primary and waterflood methods in the field. The ISGS study suggests that geologically targeted infill drilling combined with

selective, well-designed waterflooding may be able to recover a large portion of the remaining primary reserves. Ongoing studies will continue to examine how to maximize production from this heterogenous field.

- **Lawrence Field,** *Whitaker, Grube, Cole* A study of the Cypress reservoir in this field located in Lawrence County, Illinois, will entail examination of more than 40 cores and analyses of information from more than 500 oil wells. Marathon Oil Company will supply critical information. This study will provide important data from a significant oil-producing area of Illinois.

- **Mattoon Field,** *McGee* Located in southwest Coles County, Illinois, this field is a 6,680-acre anticlinal trap that was discovered in February 1939. Less than half of the total 667 completions are active today. Principal production is from the Mississippian Cypress, Aux Vases, and Rosiclare Sands and also from lower Mississippian and Devonian-aged intervals. The initial phase of this project focused on intraformational relationships. The project is now delineating individual sands within the Cypress Formation. Preliminary results indicate extreme reservoir heterogeneity. Significant progress continues toward mapping individual and genetic sand packages within the Cypress.

- **Oakdale and Markham City North Fields,** *Crockett* The Oakdale Aux Vases pool study was expanded to include Markham City North Field, a combination Ste. Genevieve carbonate and Aux Vases sandstone reservoir located about 1½ miles east of Oakdale on the border between Jefferson and Wayne Counties. Structure, isopach, and facies maps depict a shallow water, tidally influenced, mixed carbonate and clastic depositional environment. Whole-rock analysis of cores and microscopic examination of thin sections suggests the reservoir exhibits similarities to other Aux Vases reservoirs included in the ISGS Aux Vases improved oil recovery study. The presence of clay minerals coating sand grains may have prohibited precipitation of calcite cements here as in other fields. Permeability in high-quality reservoir zone appears to be related to presence of clay minerals, absence of calcite cement, and sand grain-size distribution. These depositional and diagenetic factors combined with structural deformation, result in a combination structural-stratigraphic trap at both Oakdale and Markham City.

- **Parkersburg Area,** *Seyler* Cypress reservoirs have been identified in the Lower, Middle, and Upper Cypress sandstones in a 30-square-mile area in the vicinity of the Parkersburg Field in Richland and Edwards Counties, Illinois. Each of these sandstones has been mapped and production data gathered for each Cypress pool in the area. Examination of 37 sample sets has been completed in the area; strip logs and samples were picked for thin sections where sample set quality was high enough. Depositional environments identified on the basis of geometry have been verified by sample description and cross sections. Thin sections have been analyzed and a diagenetic sequence for these reservoirs has been established. Production data on a lease basis has been collected and computerized.

- **Richview Field,** *Grube* Richview Field has produced more than 3.2 million barrels of Cypress oil from 86 wells on 800 acres to date. Although some production is attributed to an upper discontinuous sandstone that immediately underlies the Barlow Limestone, the majority of the oil has been produced from the upper 20 feet or less of a sandstone that lies in the middle portion of the Cypress Formation. This sandstone varies in thickness from 20 to 50 feet and displays a very clean, blocky SP log character. Increases in thickness occur as incremental, blocky sands, 10 to 20 feet thick, and indicate a stacking of genetic depositional units. Log indications show thin, laterally traceable shales separate these sand units. The northeast-southwest-trending field appears to be largely stratigraphically controlled. The sandstones rapidly grade to shale away from the field.

- **Stewardson Field,** *Rice and Cole* The report on reservoir characterization of the Mississippian Aux Vases Formation at Stewardson Field in southeastern Shelby County, Illinois, is in peer review. Tasks completed as of this date include analysis of geophysical logs, development of interval isopach maps, structure maps on both the Ste. Genevieve and Beech Creek Formations, cross sections derived from the logs, petrographic analysis of well cuttings and core biscuits, geochemical analysis of oil and brines, clay analysis, volumetrics, and the determination of depositional environments and the diagenetic sequence.

- **Tamaroa Field,** *Grube* Reservoir heterogeneity and pressure maintenance are controlling factors on cumulative production and ultimate recovery efficiency in this Cypress reservoir. Maximum production is obtained by draining and pressure-maintaining one distinct, correlative sandstone from

a vertically stacked, multilateral marine bar setting. Both marginal and successful production programs are apparent within the multiple oil reservoirs of Tamaroa and Tamaroa South fields. Recovery of 40,000 to 60,000 barrels of oil per well from 10-acre spacing and less than 10 feet of reservoir thickness are typical where pressure is maintained within one distinct, correlative sandstone body. A manuscript describing the Tamaroa Field is in peer review.

- **Xenia East Field,** *Xu* A pool study of the Cypress reservoir at Xenia East Field includes production information and analysis of stratigraphic, structural, and diagenetic factors that affect oil recovery and field development. Subsurface mapping has identified seven distinct sand bodies, but only two form hydrocarbon reservoirs. One sand body forms the primary reservoir, with 17 producing wells. Numerical models to predict original oil in place are being examined, and work continues on examining the petrographic character of the reservoir.

- **Zeigler Field,** *Seyler* Porosity, permeability, lithology, and cumulative production data for all wells in the Zeigler Field have been computerized. Producing wells coincide with the clean sand isopach. This Aux Vases reservoir has a high degree of both lateral and vertical heterogeneity. Calcite cement dissolution in the horizontal direction and microfractures in the vertical direction are postulated as permeability controls.

Regional studies included the following:

- **Regional Petrographic Study for the Aux Vases Sandstone,** *Seyler* A regional paleochemical (diagenetic) sequence for reservoir development has been generated for the Aux Vases Sandstone in Zeigler (Franklin County), Energy (Williamson County), Thompsonville (Hamilton County), and Oakdale Fields (Jefferson County). This study includes correlation of thin-section, SEM/EDX, and XRD analyses with interpretations of similarities in depositional processes, reservoir geometries, and wireline log responses of reservoir rocks. To date, results indicate that similar modifications during and after deposition are responsible for development of reservoir facies in the Aux Vases over the study area. Knowledge of reservoir similarities will permit testing of specific technologies for improving production efficiency thus forming an essential part of the Illinois Improved and Enhanced Oil Recovery project. A poster paper on this subject was presented at the American Association of Petroleum Geologists annual meeting in April 1991 in Dallas, Texas.

- **Regional Study of the Aux Vases and Cypress Formations,** *Whitaker, Leetaru, Cole* Data from wells throughout the state are being compiled for a regional study of the relationships between outcrop exposures, subsurface stratigraphy, and hydrocarbon reservoirs. Cross sections showing stratigraphic changes within these formations and maps showing reservoir distribution will be constructed covering the entire oil-producing portion of Illinois.

- **Outcrop Study of the Aux Vases and Cypress Formations,** *Cole and Haggerty* Thirty outcrop sections of the Mississippian Cypress Formation were analyzed for stratigraphic sedimentological, and depositional histories. Eighty samples were collected for petrographic analysis. The Lawrence Field study includes description of seven cores that were sampled for thin-section preparation.

- **Improved Methods of Subsurface Analyses,** *Leetaru* The study analyzing the use of old electric logs was published as Illinois Petroleum 134, *Application of Old Electric Logs in the Analysis of Aux Vases Sandstone (Mississippian) Reservoirs in Illinois.* In this report, old electric logs were used effectively to estimate porosity and water saturation. The empirical methods described in this report are quick and easy to use. Results of the analysis can be used to help identify bypassed pay in older wells and to provide input into reservoir models.

- **Clay Mineralogy of Reservoirs,** *Beaty, Hughes, Moore* Clastic and carbonate samples from Cypress and Aux Vases oil-field cores, selected for clay and bulk mineral analysis, were collected from whole and reduced cores and core plugs. More than 200 samples were analyzed in support of the oil and gas field studies to establish the impact of mineralogy on reservoir behavior. Significant variation has been observed for the bulk content of minerals, the types of clay minerals, and the correlation between clay mineral type and bulk mineral content. A QA/QC audit was conducted, and refinements were made in analytical techniques.

- **Improved Recovery Through Characterization and Prediction of Fluid-Rock Interactions,** *Haggerty, Sims, Udegbunam* Relationships and interactions between the composition and

mineralogy of reservoir rocks and naturally occurring and introduced fluids are being investigated to seek further insights into improving and enhancing oil recovery.

- **Geochemistry of Reservoir Fluids,** *Demir* The main research objectives are to characterize and model chemistries of reservoir fluids to predict (1) paleochemical (diagenetic) reactions that influenced porosity and permeability, and (2) changes in reservoir properties in response to the injection of enhanced oil recovery fluids. During this period, 39 brine and 19 oil samples were collected from the Aux Vases and Cypress formations. The samples are being analyzed for various geochemical paramters and the areal distributions of the measured geochemical parameters will be mapped. The analytical data will also be used as input for computer modeling codes for predictive geochemistry for the purpose of avoiding formation damage that decreases production.

- **Mineralogy of Chlorites**, *Moore, Hughes, Glass* Chlorite minerals affect the porosity and permeability of petroleum reservoir rocks. They are often important reactants to fluids introduced into reservoirs, causing man-induced decreases in porosity and oil production. Investigations are underway to quantify the impact of these minerals on both the chemical and physical constitution of chlorites. Small amounts of serpentine-like (soapstone) mixed-layering in the chlorites from Aux Vases and Cypress sandstone oil reservoirs have recently been identified and efforts are being made to estimate the iron, aluminum, and magnesium contents of chlorites. Findings of these studies will be correlated with the fluid flow properties of the rocks. Recent results show little correlation between occurrence of varieties of chlorite and reservoir properties.

Engineering studies were introduced:

- **Engineering Core-Cleaning Study,** *Haggerty* A study of the effects of temperature during core cleaning is underway. Core cleaning is necessary so that hydrocarbons can be reintroduced to core devoid of hydrocarbons and hydrocarbon behavior studied in an environment characteristic of the pristine reservoir. If the mineralogy, in particular the clay mineralogy, changes during cleaning, then hydrocarbon behavior would not reflect actual reservoir conditions. Twelve Aux Vases plugs from Energy Field were cleaned in the $CO_2$/solvent core cleaner and dried in a vacuum oven at various temperatures and the preliminary rock property results are currently being analyzed.

- **Compilation and Assessment of Illinois Oil Field Engineering Reports,** *Rice* A review and inventory of engineering and geologic reports given to the ISGS has been completed and a list has been distributed to section staff. The waterflood feasibility, valuation, prospect, and well site reports and lease evaluations include some core analyses and data pertaining to the performance of the Aux Vases and Cypress reservoirs under study.

**New Exploration Methods and Concepts**

**Analysis of Gravity Data in the Salem Area, Illinois**, *Heigold, Whitaker, Lecouris, Leetaru* Proprietary Bouguer gravity anomaly data covering parts of Fayette, Marion, Effingham, and Clay Counties have been obtained by the ISGS. Gravity readings (nominally accurate to 0.01 mgal) were taken at 2,122 stations spread over 685 square miles (station spacing = c. 0.5 miles). The high quality of these data provides an excellent opportunity to isolate that portion of the gravity field due to lateral density contrasts in the sedimentary rocks. Relationships between residual gravity anomalies and both known and unknown geologic structures bearing hydrocarbons are sought.

**Clay Mineral Indicators of Petroleum Formation and Migration,** *Moore, Hughes, Crockett, Seyler, Shaw, Glass, Austin* A way is being investigated to differentiate clays that were deposited during sedimentation from those that chemically formed after the sediments were deposited. The latter are related to the thermal conditions required for the formation, movement, and emplacement of hydrocarbons. Investigations have begun on the clay mineralogy of the Maquoketa Group shales and the St. Peter Sandstone.

**Tar Springs Sandstone Hydrocarbon Reservoir in Sailor Springs Consolidated Field,** *Howard* Key factors in the entrapment of hydrocarbons in Tar Springs sandstone bodies are (1) the depositional environments of the sandstones and associated shales, and (2) the subsequent tectonic (folding) history of the units. Preliminary maps and cross sections based on data from more than 2,000 electric logs show the thickness and areal distribution of Tar Springs lithologic units within the 130-square-mile study area.

An anastomosing (interconnected) system of linear sandstone bodies ranging up to 130 feet thick and over 1.5 miles wide strikingly resembles Pleistocene sand-filled river channels off the gulf coast of Louisiana. The Pleistocene river channels crisscross an early deltaic complex of the Mississippi River, a recent analog to the ancient Tar Springs depositional environment. Numerous similarities have been observed between the Tar Springs and other Chesterian sandstones (e.g., Cypress) by Oil and Gas Section members who are studying Cypress sandstone reservoirs across southern Illinois.

### Hydrocarbon Generation and Migration Studies

**Source Rock Studies of the Ordovician Maquoketa Group,** *Crockett and Shaw* Potential hydrocarbon source rocks in the Ordovician Joachim and Dutchtown Formations are being studied in cooperation with a Ph.D. candidate in geology, Tom Shaw, who is conducting dissertation research in the Illinois Basin. Rock-Eval analyses from Joachim and Dutchtown core samples from White County and Montgomery Counties, Illinois, reveal that these rocks are poor in the organic material necessary to serve as a hydrocarbon source rock and are submature in terms of hydrocarbon generation. The data indicate that the Joachim and Dutchtown Formations are not likely to be favorable source rocks at these locations. Continued analysis of samples from more widely distributed locations across Illinois will further characterize the hydrocarbon source potential in these rocks.

**Geochemistry of Natural Gas,** *Riley, Liu, Coleman* Natural gas samples collected as part of our oil, gas, and water well-testing programs, along with samples submitted by individuals and by industry, are analyzed to determine their chemical and sometimes isotopic compositions. This information, which adds to our basic database on the geochemistry of natural gas in Illinois, is frequently used to distinguish gases from different sources and to help solve both production and environmental problems. During the reporting period, 70 natural gas samples were analyzed and one natural gas well was flow tested.

At the request of the homeowner, a site was visited in Champaign County. The basement sump had "caught on fire" and a portable gas detector indicated a high percentage of combustible gas venting from the sump a day later. One cause could have been drift gas (bacterially produced methane within the glacial drift), which is common in the area. Analysis of gas samples showed, however, that the problem was caused by a leaky pipe connecting a propane fuel tank to the home. The homeowner replaced the damaged pipe and has had no further problems.

### Oil and Gas Database Management

**VAX 3800 AND VAX 3200 System Management,** *Lecouris and Yeko* The operating system was upgraded to v5.2 to support the application software upgrades from Geoquest and Zycor. Ten additional user accounts were added to the systems. The GeoQuest application software was upgraded to the newest version and one new application was installed. Several new users were added to both systems.

### Technology Transfer and Information Services

**Technology Transfer for Improved and Enhanced Oil Recovery Project,** *Oltz and staff* The paper, "Aux Vases Sandstone: Zeigler Field, Franklin County, Illinois," was presented at the Eastern Section AAPG meeting in September 1990. The invited paper, "An Integrated Approach to Reservoir Characterization in the Illinois Basin," was presented at the Fifth International Archie Conference in October 1990.

The Oil and Gas Section presented poster-style display booths showcasing the work in progress at the Illinois Oil and Gas Association meeting in March 1991, which was attended by approximately 400 local geologists, oil company operators, and service company representatives. A similar display was presented at the national American Association of Petroleum Geologists (AAPG) meeting in April 1991 in Dallas, Texas, which more than 6,000 petroleum industry attended. Presentations at the AAPG meeting included the paper, "Varieties of Chlorite and Illite in Mississippian Sandstones in the Illinois Basin"; a description of the paleogeographic reconstruction of the Illinois Basin during deposition of the Aux Vases; a talk on "Long-Range Petroleum Migration in the Illinois Basin"; and the description, "A Comparison of Reservoir Heterogeneity and Recovery Efficiency of Two Offshore Bar Complexes in an Intracratonic Basin."

Invited talks describing the improved and enhanced oil recovery project in the Illinois Basin were presented by Oltz to the Illinois Oil and Gas Association in March; Illinois Oil Producers Association in June; the Kentucky Oil and Gas Association in June; and the Illinois Stripper Well Owners and Royalty Association in May. At the Illinois Geological Society meeting in February, Oil and Gas Section geologists Huff and Whitaker made presentations on the Siggins oil mine project and the Bartelso Field Cypress reservoir study.

**Field Investigations of the Aux Vases and Cypress Formations** Two manuscripts have been submitted for review: the first, a historical and stratigraphic analysis of the Mississippian Aux Vases Formation, and the second, a petrographic investigation of the Aux Vases. Additional manuscripts in preparation include a synthesis of Cypress Formation exposures and a comparison of outcrop and subsurface examples in the Aux Vases Formation. An abstract has been submitted for the Annual Meeting of the Geological Society of America in October 1991.

**Reservoir Classification** The U.S. Department of Energy (USDOE) invited a team of seven geologists to meet in Dallas, Texas, on January 15-17, 1991, to finalize a classification system for clastic and carbonate reservoirs across the United States. D. F. Oltz, head of the ISGS Oil and Gas Section, presented the results of a study, funded by the Interstate Oil Compact Commission, of seven northeastern states, including Illinois. Oltz also participated in preparation of a final report to the USDOE. The final products from the meeting have been used to document remaining reserves in the United States by reservoir class, and were used to provide information to the USDOE as a basis for their research program in oil and gas.

**Computer-Generated Oil and Gas Development Maps Project,** *Frankie and Oltz* Project objectives include development of a computer-generated series of maps that will replace the older ISGS series of hand-drawn Oil and Gas Development Maps. These maps are used to show the status of oil and gas wells (oil, oil and gas, gas, abandoned, converted) and to show the locations of wells. Computerization will allow updates and keep the maps current.

The new series of computer-generated Oil and Gas Development Maps are at a scale of 2 inches = 1 mile (1:31,680). The new maps show well location and status derived from data deposited with the ISGS Geological Records Unit. Each map includes county, township, range, and section lines and the names of oil and gas fields. Map areas are generally three townships by three ranges in extent. The first six computer-generated Oil and Gas Development Maps have been completed and are available to the public both in color and by diazo reproduction: Du Quoin (No. 24), Roaches (No. 33), Mt. Vernon (No. 34), Fairfield (No. 35), Xenia (No. 42),

**Clay Mineralogy of Two Mississippian Sandstone Reservoirs in the Illinois Basin**, *Moore and Hughes* This paper was presented at the Annual Clay Mineral Society in Columbia, Missouri; it was part of a Symposium on Clays in Sandstone Reservoirs.

**Semi-Annual PAC/TAC Meeting, Mt. Vernon, Illinois** This one-day meeting was a dialogue between ISGS researchers and industry representatives to discuss progress and solicit input on the ENR/USDOE Improved and Enhanced Oil Recovery Program. The meeting included posters of field studies, oil and gas development maps, seismic modeling, and geochemical modeling and a demonstration of the CONQuEST system of data entry and retrieval. Industry response was positive and led to enthusiastic support for the program.

## OTHER ENERGY SOURCES

The increasing amount of oil imports, the finite reserves of domestic fuels, and the environmental impact of coal consumption make exploration of the availability and use of domestic alternative fuels imperative, especially those with minimal environmental impact and lower cost. Two Illinois Basin sources of gas commanded attention during the year, shale gas and coal mine gas. Both require further evaluation. To date, the limited shallow gas resources of the Illinois Basin have provided energy locally for homes and farms. Also, deeper potential sources of natural gas in the Illinois Basin remain unexplored.

**Coal Mine Gas,** *Riley, Liu, Coleman* At the request of various gas well producers and operators, coal mine gas wells have been tested for gas composition and flow rate. These are gas wells that have been completed into abandoned (and sealed) coal mines. The remaining coal in these mines continues to produce methane gas, and a new study indicates that a significant amount of methane could be produced. As a result, interest in the quality and quantity of coal mine gas has increased.

**Evaluation of Gas Potential of New Albany Shale (Group) (Devonian-Mississippian) in the Illinois Basin,** *Frankie and Lumm* This cooperative study with the Indiana and Kentucky Geological Surveys is funded by the Gas Research Institute. The objectives of this study are to update, compile, review, and reinterpret all pertinent literature, maps, and unpublished data useful for assessing the gas potential of

the New Albany Shale in the Illinois Basin. Progress to date includes (1) completion of four statewide stratigraphic cross sections and one structural cross section; (2) compilation of a 1:1,000,000-scale digital base map of Illinois, Indiana, and western Kentucky; (3) generation of computer-contoured draft maps of the structure and thickness of the New Albany Shale in Illinois; and (4) cooperation with gas producers and independent operators in the Illinois Basin to obtain recent drilling and production data. Products of this study will include a final published report containing basinwide cross sections and maps (scale 1:500,000) of thickness and structure. These publications will be made available by the Illinois, Indiana, and Kentucky Surveys and the Gas Research Institute.

**Coal Mine Methane,** *Frankie and Damberger* Currently, in four drilling operations in Williamson, Franklin, and Saline Counties, wells have been completed into abandoned coal mines in order to access the availability of methane from abandoned coal mine workings. During the last year, responses were made to several requests for information on coal-bed and coal-mine methane resources. The results of these evaluations are being held confidential by the companies involved. The ISGS supplied information on coal-bed methane desorption data, maps of abandoned coal mines, and data on the thickness and depth of coal seams. Additional data supplied to the industry consisted of paper copies of out-of-print ISGS publications and data assembled from other publications on coal mines.

## GROUNDWATER RESOURCES

The hydrogeologic research effort this year for groundwater resources has been concentrated on two major projects funded by the Illinois Department of Energy and Natural Resources (ENR) as part of the Aquifer Assessment Program. These projects are multiyear projects that began in FY90 and include a 5-year assessment of some major aquifers in the Prairie Aquigroup and a 4-year study of the shallow bedrock aquifers of northern Illinois.

In addition to these regional projects, water resources investigations are conducted for local governments. Five studies are being conducted in Kane County: reports for four are in the final production stage, and field work is being conducted for the newest study near North Aurora.

Plans were developed in 1990-91 for expanding the research effort to include hydrogeological systems, and they will be described more fully in the next annual report.

The service workload in groundwater resources has remained at approximately the same level as last year. Requests for groundwater reports and electrical earth resistivity surveys were down, whereas sieve analyses and borehole logs were up. Telephone responses remained at the same level (averaging more than 100 per month) as last year.

### Groundwater Assessment

**Prairie Aquigroup Assessment**, *D. Larson, Herzog, Kempton, Anderson, Vaiden, Chenoweth (ISGS); Carrillo (NIU)* This 5-year project began in FY90 as part of the Aquifer Assessment Program funded by ENR. Three areas will be covered over the course of the project. Initial focus is on the Green River Lowland, which includes parts of Whiteside, Lee, Rock Island, Bureau, and Henry Counties. Significant groundwater resources are found in this area in both bedrock and glacial drift aquifers. Some areas of the Lowland are heavily irrigated and groundwater use is significant. Due to heavy irrigation, the potential for groundwater contamination by agricultural chemicals is a concern, especially where the aquifers occur at or near land surface. Although the area is heavily irrigated, little previous detailed work has been carried out. Therefore, a comprehensive understanding of the hydrogeologic setting of the aquifers is being developed to provide a solid basis for addressing issues relating to groundwater quantity and quality.

Collection, tabulation, and analysis of data from the Green River Lowland is progressing, facilitated by the use of computer spreadsheets. Well locations in all five counties are being verified. Draft bedrock topography maps have been produced from Bureau, Henry, and Whiteside Counties. Other mapping in progress for all five counties pertains to aquifer thickness, thickness of confining units, and the potential for groundwater contamination. Several draft cross sections have been drawn for Bureau, Henry, Lee, and Whiteside Counties.

Under a subcontract, Northern Illinois University is studying the Paw Valley, at the northeast edge of the study area. The NIU study will result in a master's thesis, which will be defended in early FY92.

**Upper Bedrock Aquifer System in Northern Illinois,** *T. Larson, Graese, Orozco* A multiyear investigation of the hydrogeology of the important carbonate rock groundwater resource began in 1989. The rocks of the shallow carbonate bedrock are widely used as a groundwater resource in northern Illinois. They are also highly susceptible to contamination. The first area selected for study is the region underlain by Silurian-age bedrock in northwestern Illinois. Petrographic analysis and porosity measurements of samples of cores from the ISGS Samples Library are providing the basic data that will be supplemented by drill cuttings. A new map of the bedrock surface in this area will be prepared.

**Groundwater Resources in Bedrock Valley Aquifers,** *Chenoweth, Herzog, McKay, Eidel (ISGS); Avery, Warner, Martin (USGS)* This project, which covered the entire state, was designed to better define valleys in the bedrock surface. Bedrock valleys commonly contain deposits that can be important sources of groundwater in scattered locations. Draft maps, which updated older bedrock topography and drift thickness maps along known bedrock valleys, were delivered to ENR in FY90. The ISGS is currently working with the USGS to digitize the bedrock topography map to make future updates much easier.

**Groundwater Resources in Kane County,** *D. Larson, Morse, Orozco (ISGS); Fitzpatrick (USGS)* Four detailed studies were conducted of groundwater resources in the glacial drift and shallow bedrock of Kane County. The studies were supported by funding from county and local municipalities and the Division of Water Resources of the Illinois Department of Transportation. Areas receiving detailed study were the Aurora area, the Geneva-Batavia area, the St. Charles area, and the Fox River Corridor. The studies successfully identified aquifers with large potential groundwater supplies. All four final reports will appear in the ISGS Open File Series.

A new study was funded by the Village of North Aurora to locate a shallow aquifers in south-central Kane County. The general hydrogeologic setting had been previously defined in the ISGS Contract/Grant Report, *Hydrogeology of Shallow Groundwater Resources, Kane County, Illinois.* Detailed geophysical studies, which are currently underway, will provide more precise information prior to test drilling.

**Will and Southern Cook Counties,** *E. Smith* The ISGS, under an agreement with the Illinois State Water Survey (ISWS), is constructing geologic and hydrogeologic maps and cross sections for Will County and the portion of southern Cook County bordered by Will County, the Calumet-Saginaw Channel, and the state line. The primary goals of the project are to delineate areas with extensive sand and gravel aquifers, particularly where sand and gravel aquifers are in contact with the Silurian-age dolomite bedrock. A Silurian bedrock thickness map is also being developed. Data from this project are essential for accurate hydrologic modelling of the study area by the ISWS.

Existing data were collected and reviewed for accuracy and completeness. Water well records and other subsurface information were entered into a computer database designed to update existing information and to facilitate the generation of the maps and cross sections by using geologic mapping software.

**Springs in Illinois,** *D. Webb and M. Wetzel* (Illinois Natural History Survey [INHS]); P. Reed (ISGS) Springs are naturally occurring collective points of groundwater discharge that appear at the surface as flowing water. A cooperative spring study funded by the Nature Preserve Commission was initiated with the INHS to determine momentary flow, water chemistry, and biological diversity at six springs in Hardin, Jackson, Gallatin, and Union Counties in southern Illinois. Hydrogeologic considerations will form the basis for classifying the springs according to topographic and geologic setting, structure type, and discharge rank.

**Interpretation of Geothermal Surveys,** *T. Larson and Cartwright* Geothermal prospecting for groundwater, a method that uses small variations in ground temperature to locate shallow aquifers, was conceived by ISGS scientists in the 1960s. A computer model of heat and water flow in soils has been combined with field data from ISGS investigations to improve understanding of the fundamental processes underlying these surveys. Results of this research were submitted for publication to the journal, *Geophysics and Ground Water.*

### Technical Assistance

**Resistivity Surveys,** *P. Reed* Resistivity (electrical) surveys are useful for interpreting the sequence of earth materials and water quality. Surveys for sand and gravel aquifers were conducted at 52 locations where test drilling had failed to reveal an adequate groundwater supply. Included were studies for seven municipalities, two government agencies, two public water suppliers, one industry, 13 farms, and 27 private acreages in Illinois.

**Borehole Geophysics,** *P. Reed and Orozco* Borehole logs provide graphic records of the chemical, physical, and acoustical characteristics of saturated and unsaturated earth materials. A new sonic sonde was purchased to improve the capability for determining permeability and porosity. Borehole logs are the most common geophysical data used by geologists, hydrologists, and engineers; they are frequently used in ISGS research. Logs are run in fluid-filled or air-filled open and cased boreholes. Borehole logs are used for aquifer evaluation to complement electrical earth resistivity surveying and for stratigraphic analysis of unconsolidated and consolidated earth materials. During FY92, 87 borehole logs were run at 66 sites. In May, the ISGS logging team assisted the engineer of the Rockford Regional Office, Illinois Department of Public Health (IDPH), to evaluate possible contamination of a 450-foot supply well for the Illinois Department of Transportation (IDOT) at the Long Hollow Scenic Overlook in Jo Daviess County. The study was a joint project between the ISGS, the IDPH, and IDOT.

### Technology Transfer and Information Services

**Service Requests for Groundwater and Geologic Information,** *Brower, P. Reed, E. Smith, Herzog, and staff* Requests for information were received by the Hydrogeology Section from well drillers, farmers, citizens, industries, and governmental agencies desiring to locate, develop, use, and evaluate groundwater resources. Responses included approximately 1,400 phone calls, 150 letters, 66 groundwater possibility reports, and two preliminary hydrogeologic evaluations of proposed waste disposal sites. Thirty-nine sieve analyses were performed for nine municipal test holes and two state agency test holes. Sediment samples from one water well were examined to determine which formation was the source of the sediment. Approximately 80 people visited staff of the Hydrogeology Section to seek information.

**Water Use Act Activities,** *E. Smith* Under the provisions of the Water Use Act of 1983, the ISGS and ISWS provided technical assistance to the staffs of County Soil and Water Conservation Districts by assessing the potential impacts of high-capacity water wells on the groundwater resources of the surrounding region. During the last half of this fiscal year, the receipt of approximately 127 site evaluation requests was acknowledged by the ISGS. A computerized database, consisting of information submitted with the evaluation requests and subsequent actions taken by ISGS staff, is being developed to enhance future project efforts.

## INDUSTRIAL MINERALS

The Industrial Minerals and Metals Section has the major, mandated responsibility for ISGS research and service work related to the nonfuel mineral resources of Illinois. Programs carried forward within the section include resource mapping, field studies of known mineral deposits and orebodies, laboratory investigations of the chemical and physical characteristics that relate to the quality of deposits and specifications for their use, and studies designed to promote environmentally sound extraction and the best use of resources.

In 1989, industrial minerals and metals provided approximately 17 percent of the dollar value of minerals extracted in Illinois. The value of industrial and construction materials mined in Illinois amounted to $473.1 million (mostly from crushed stone and sand and gravel). The importance of industrial and constructional commodities to the economic well-being of the state and nation, especially in the transportation, construction, and chemical sectors, needs to be better recognized.

Time and effort were expended in support of the mineral assessment of the Paducah 1° × 2° Quadrangle under the Conterminous US Mineral Assessment Program (CUSMAP) sponsored by the U.S. Geological Survey (USGS). This cooperative project with the USGS and the adjacent states of Kentucky, Missouri, and Indiana is nearing completion; a public disclosure meeting is scheduled for late January 1992. As an outgrowth of the CUSMAP program, an assessment of the mineral resources of the Shawnee National Forest was provided to the U.S. Forest Service.

Other research areas that have received special attention during the past fiscal year include the microcrystalline silica deposits (tripoli) of southwestern Illinois, dolomite resources of the greater Chicago area, and testing of a new grinding process using a computerized mill designed at ISGS. Service work and requests for geologic and resource information have dealt with the broad spectrum of the state's industrial minerals including sources of aggregate materials to serve urban markets and sources of high-calcium limestone and other materials for use in $SO_2$ scrubbers.

## Mineral Resource Assessments

**Paducah CUSMAP Project,** *Eidel, Baxter, McKay, staff* An evaluation of the mineral resource potential of the Paducah 1° × 2° Quadrangle (Kentucky, Illinois, Indiana, and Missouri) is being carried forward by the USGS as part of CUSMAP and with the cooperation of the four states. The objective is to compile all existing geological, geophysical, and geochemical data; identify and acquire needed new information to fill gaps in the database; and complete an in-depth evaluation of the fluorspar, barite, base metal, beryllium, thorium, rare earth, industrial minerals, oil and gas, and coal potential of the Paducah Quadrangle including all of southern Illinois south of the latitude of Benton. Of 52 genetic models for mineral deposition that have been evaluated, some 24 appear to be applicable.

From April 24 to May 3, 1991, representatives of the Illinois, Kentucky, Missouri, and Indiana Geological Surveys and the USGS met in Champaign to evaluate the use of the Illinois Geographical Information System (IGIS) for assessment of the minerals potential of the Paducah 1° × 2° Quadrangle. The exercise, utilizing various genetic models, represented the first successful use of GIS in the national CUSMAP program. Assessment of a tripoli model and a complex vein fluorspar model was completed. Plotting of final assessment maps delineating areas of high, medium, and low potential and high, medium, and low confidence will be carried out. Assessment for other commodities and the remaining models continues. The project will culminate with economic release at a public meeting in January 1992 in St. Louis, Missouri.

Paducah CUSMAP products with major ISGS contributions are as follows:

- **CUSMAP Database**, *Pool, Stiff, Junkins, Helm, Denhart, Smith, McKay* An extensive database of maps and tabular data was compiled and documented for the Paducah CUSMAP assessment. The database is under update and revision and will be used as the basis for 24 mineral resource potential models. The data sets are being managed with GIS software on ISGS computer workstations to assure that appropriate GIS expertise and computing capacity are available to the project.

- **Bedrock Geologic Maps,** *Nelson* A first draft of the map was produced by the Geologic Mapping and Digital Cartography Section at the ISGS. A report, originally in four parts, covering the four quarters of the Paducah Quadrangle, has been rewritten into a single manuscript covering the entire Quadrangle. This report is in administrative review.

- **Surficial Deposits and Stack Map,** *Berg and Greenpool* The surficial materials map has been completely digitized. A unique system of color shading and using line and dot patterns is used to display more than 130 stack-unit combinations of geologic materials. Regional geologic provinces are depicted by major color differences. Line and dot patterns differentiate generalized material properties and sequence characteristics. The map will be used to determine the depth of prospective industrial mineral resources and the location of sand and gravel resources.

- **Mines and Prospects,** *Baxter* Digitization of the location of all known noncoal mines, pits, quarries, and prospects within the Paducah Quadrangle and compilation of point source data supplied by the individual states was completed in GSMODS and then converted to ARC/INFO for use in GIS assessments. Commodities produced in Illinois and the number of sites included in the database are fluorspar, base metals and barite (270), tripoli (121), sand and gravel (60), clay and shale (46) and limestone (33).

- **Detailed Core Descriptions for CUSMAP**, *Lasemi and J. Treworgy* Two cores of the lower Chesterian and upper Valmeyeran section (Mississippian) from Hardin and Pope Counties were described in detail for the basin modeling to be done by USGS and ISGS staff for CUSMAP.

- **Cross Sections Through Southern Illinois, Southeastern Missouri, and Western Kentucky**, *Sargent, J. Treworgy, Whitaker* Three structural cross sections of the entire Phanerozoic succession above Precambrian crystalline basement were constructed through the key deep wells in southern Illinois and adjacent parts of southeastern Missouri and western Kentucky. A west-east section displays the structural elements and stratigraphic relationships of the strata as they occur onlapping the Ozark Dome, dipping into the Illinois Basin, crossing through the Illinois-Kentucky Fluorspar District, and ending in the Rough Creek Graben, Webster County, Kentucky. Another section, northwest-southeast trending, begins on the Sparta Shelf in southwestern Illinois, and crosses the DuQuoin Monocline as it passes into the central part of the Illinois Basin. Within the basin, it passes through the Cottage Grove Fault System, Hicks Dome, and the Fluorspar Area Fault Complex as it

passes into the Rough Creek Graben south-southwest of the eastern end of the first section. The third, a northeast-southwest-trending section that completes a triangle in extreme southern Illinois, begins near the center of the Fairfield Basin, Wayne County, passes through the Dale Dome in Hamilton County, passes through the Cottage Grove Fault System, intersects a faulted flexure in southwestern Union County, and ends within the Mississippi Embayment in southeastern Missouri.

In addition to the structural features encountered, major stratigraphic features observed include thickening of the units from the Ozark Dome into the Illinois Basin and Rough Creek Graben, eastward pinchout of the Davis Shale, erosional beveling of the top of the Prairie du Chien Group in the Rough Creek Graben, and eastward thinning of the Galena (Kimmswick) Group. These results were presented at the Louis Unfer, Jr., Conference in Cape Girardeau, Missouri, on June 13-14, 1991.

- **Isopach and Lithofacies Maps in the Paducah Quadrangle,** *Sargent* Isopach and lithofacies maps were prepared of nine units within the Paducah 1° × 2° Quadrangle and adjacent areas. Parts of this work were carried out jointly with the adjacent states of Kentucky, Missouri, and Indiana in cooperation with the USGS. These maps include units that may be host rocks for ores or may have been instrumental in the formation of ores. Units mapped include the St. Peter Sandstone, Everton Dolomite, Ottawa Supergroup, New Albany Group, Lower and Middle Devonian Series, Mt. Simon Sandstone, Eau Clair/Bonneterre Formation, and Knox Supergroup.

- **Surface of the Precambrian Basement in Southern Illinois and Adjacent Missouri and Kentucky,** *Sargent* The map of the surface morphology of Precambrian crystalline rocks has been completely revised using seven recently acquired pieces of seismic reflection data. These data have provided the first nonproprietary information on the center of the Paducah Quadrangle. Only one basement test has been drilled within the quadrangle; two others fall within a few miles of it.

- **Data Set of 138 Wells and Other Boreholes in and Adjacent to the Paducah Quadrangle,** *Sargent and Lasemi* A data set of 138 key wells in and around the Paducah 1° X 2° Quadrangle was prepared at the ISGS and shared with the USGS. These data will be used extensively in the assessment of the Paducah region as the potential site of mineral resources of all types. In addition to the short term CUSMAP uses, this computer-based data set will be used in studies by the Illinois Basin Consortium, the ISGS, and the USGS to study the subsidence history, tectonic history, and resource potential of the entire Illinois Basin region.

- **CUSMAP Computer Modeling for Mineral Resource Assessment,** *Pool, Stiff, McKay* Staff prepared GIS programs and databases for the week-long modeling exercise involving geologists from the USGS and the Illinois, Kentucky, Missouri and Indiana Geological Surveys. The purpose was to prepare computer models of minerals resource occurrences and maps representing the relative likelihood of occurrence of previously unknown mineralization. Working with the economic geologists, the ISGS computer staff prepared maps of model results as the workshop participants refined and developed conceptual models. The project will continue using methods developed during the workshop to complete models during the coming months for presentation in a public meeting in 1992.

- **Subsurface Geochemistry of Limestone Formations,** *Baxter, Masters, Eidel, Klitzing, McKinney (ISGS); Goldhaber and others (USGS)* In subsurface geochemical studies of limestone formations, an insoluble residue medium was used to obtain information on the passage of ore fluids through large volumes of sedimentary rocks and to locate possible sites of mineral deposition continued during the period. ISGS involvement consisted of cutting samples from two additional oil well samples set. These were shipped to Denver where dissolution and chemical analyses were carried out by the USGS. The inclusion of these wells and an additional well or two from Kentucky completes the insoluble residue geochemical database that is being utilized for the assessment of potential for fluorspar and metallic deposits. More than 12,000 analysis have been carried out to date.

- **Mineralogy of Acid Residues for CUSMAP,** *Hughes and Moore* The mineral content of samples analyzed for valuable metal concentrations were determined to see whether major mineral and metal trends were correlated. The deepest available core contained variations in the ratios of the percentage of feldspars to quartz and the percentage of K-feldspar to plagioclase feldspar. Although the source of these variations is unknown, they may lend support to models of metallic ore formation.

- **Limestone Resource Maps,** *Baxter and L. Smith* A map showing the distribution of limestone formations with proven and hypothetical potential as sources of limestone for aggregate, high-calcium, and

building-stone uses was prepared for each of the four ½° × 1° (1:100,000 scale) sheets that constitute the Paducah 1° × 2° (1:250,000 scale) Quadrangle. These maps were digitized and first plots made.

- **Sand and Gravel Resource Maps,** *Masters and Stiff* A map showing areas with potential for economic sand and gravel and clay deposits associated with post-Paleozoic sediments was prepared for each of the four ½° × 1° quadrangles (1:100,000 scale, 1 inch = approximately 1.6 miles) that constitute the Paducah 1° × 2° sheet. These 1:100,000-scale maps were digitized and plotted out at 1:250,000 scale prior to the preliminary assessment meeting held in Champaign in April. At that time it was decided to remove the clay data and prepare a separate clay resource map. Removal of the clay data began. The final sand and gravel resource maps, scheduled for completion about September 1, 1991, will be based on available information on the distribution, thickness, and depth of potentially exploitable deposits in Cretaceous-Tertiary and Quaternary strata, as judged from ISGS surficial and stack-unit maps, supplemented by available drilling data.

- **Clay Resource Maps**, *Hughes and Baxter* The clay information taken from the post-Paleozoic resource map will be combined with information on distribution of Paleozoic clays and shales and a clay resource map prepared. Data on distribution, occurrences, quality, and overburden thickness will be used to assess potential for economically viable deposits.

- **Assessment of the Mineral Potential In the Shawnee National Forest**, *Eidel and Baxter* The ISGS participated with the USGS in a manual assessment of the mineral potential of the Shawnee National Forest. The assessment was based on preliminary data acquired for the Paducah CUSMAP project in December at the request of the U.S. Forest Service (USFS). Commodities considered included oil and gas, coal, fluorspar and metals, absorbent clay, kaolin, limestone, tripoli and sand and gravel. The results of the Shawnee assessment were delivered to the USFS for congressional consideration with respect to the Illinois Wilderness bill.

- **Magnetic and Gravity Study of the Paducah CUSMAP Quadrangle**, *Heigold (ISGS); Hildenbrand and Kucks (USGS)* This paper reviews past geophysical studies in the Paducah Quadrangle with consideration given to the mineral potential of features expressed in the potential field data.

  Aeromagnetic and gravity anomaly maps have been prepared from available digital data. The nature of the digital data allowed application of several analytical techniques to enhance and invert the anomalies and provide new interpretive information. Some geophysical anomalies correlate well with known Precambrian and Paleozoic tectonic features and aid in delineating their lateral extent and associated structures. Although the sources of some anomalies are not completely understood, observed patterns and correlations yield clues to the tectonic and magmatic evolution of the region.

- **Coal Resources,** *C. Treworgy, Bargh, Jacobson, Samson, others* Data were compiled for five maps of coal resources, two structure maps, a map of the thickness of the Pennsylvanian, and a coal industry map. A computer program was developed to allow interactive assessment of coal resources in the Paducah Quadrangle. The maps and assessment program were used in the CUSMAP assessment workshop held at the ISGS in April 1991.

- **Work on Geologic Coal Database for CUSMAP**, *C. Treworgy and Jacobson* During this period significant collection, analysis, and imputing of data for the CUSMAP project took place. Data included the stratigraphic tops for the Davis and Colchester Coals, as well as the depth of the systemic boundary (base of Pennsylvanian) that forms a significant unconformity across much of the area.

**Midcontinent Strategic and Critical Minerals Workshop,** *Baxter* The Midcontinent Strategic and Critical Minerals Program (MSCMP) is a cooperative effort being carried out by the USGS with participation of the geological surveys of midcontinent states (Wisconsin, Nebraska, Minnesota, Iowa, Missouri, Kansas, Illinois, Tennesee, Kentucky, Arkansas, and Oklahoma). The aim of the program is to assess the mineral potential of a large area that covers all or parts of 13 midcontinent states including that portion of Illinois west of the 88th parallel of west longitude. Funding at both the federal and state levels is limited.

The ISGS was represented at a workshop sponsored by the Office of Central Minerals of the USGS held in Lyon, Colorado, on May 28-30, 1991. The purpose of the workshop was to review recent MSCMP activities and plan and prioritize projects. During the next 3 to 4 years, priority for limited federal funds will be given to those projects designed to assess the potential for such commodities as rare earth

elements (REE), gold, sediment-hosted manganese deposits, Mississippi Valley type (MVT) lead-zinc deposits of the sort found in northwestern Illinois, sediment-hosted copper, metals associated with black shales, and a study of the relationship of alkali igneous intrusions of southern Illinois to fluorspar, lead-zinc, and REE mineralization.

### Limestone and Dolomite Resources

**Aggregate Resource Analysis, Northeastern Illinois,** *Mikulic* The continued depletion of known reserves, urban encroachment on existing and potential sites, and local opposition to some quarry development has resulted in an uncertain future for the economically important aggregate industry in the Chicago Metropolitan area. ISGS has an active program to aid operators in efficient utilization of known reserves and in the location of new sources. Numerous requests for information from operators, local government, and the general public are received and answered on the basis of extensive ISGS databases, current research programs, and examination of individual sites.

**Cross Section of the Paleozoic Rocks of Northeastern Illinois: Implications for Subsurface Aggregate Mining**, *Mikulic* This study, a project from the geological investigation of an Illinois site for the proposed Superconductor Super Collider, was completed and the results published in ISGS Illinois Minerals 106. Based on 30 cores drilled for the SSC project and incorporating data derived from more than 100 cores drilled as part of the Greater Chicago Tunnel and Reservoir Plan, new information contained in this report will have impact on the $100-million-per-year stone industry of the region. Various underground mining approaches are discussed as a solution to the depletion of quarriable resources and the environmental impact of surface mining.

**Inventory of Active and Abandoned Quarry Sites in Cook County, Illinois,** *Mikulic* More than 250 quarries have operated in northeastern Illinois during the last 150 years. Most have been filled and forgotten with little if any record of geology, operational history, or subsequent use. This project will provide an inventory of active and abandoned quarry sites in Cook County and determine the geological conditions for each location. Information is being derived from many sources of historical data, including university libraries, state and federal museums, and the Library of Congress. The final product will consist of detailed maps of quarry sites, geological descriptions, historical records of operations and, when ascertainable, subsequent use. Data of this type has already allowed us to respond to requests for specific site information made by the Illinois Department of Transportation, other governmental agencies, and private companies.

**Aggregate Resources of Kankakee County,** *Mikulic* Parts of Kankakee County, in particular the northern part, have the potential to provide significant quantities of high-quality aggregate for local use and to supply stone to the greater Chicago area where siting and operation of quarries are constrained by environmental concerns and urban expansion. Three new quarries have either been opened or are about to be opened in northern Kankakee County. A study of drill cores, existing quarries, and known outcrop sections has been initiated to determine the thickness, extent, and quality of the Silurian carbonate deposits in this area.

**Silurian Reef Development in Cook County—Implications Regarding Aggregate Resources,** *Mikulic* New information on the early development and basal configuration of a large Silurian reef indicates that reefs, such as those that supply major quantities of high-quality aggregate to the Chicago area, may have a ridge-like rather than a conical configuration. If so, Chicago-area reserves may be somewhat greater than previously thought.

**Limestone Resource Study in Hardin County,** *Baxter* Six diamond drill cores penetrating the Ste. Genevieve and St. Louis boundary in Hardin County were studied for information on the position of the boundary and quality of limestone. The Ste. Genevieve Limestone is a major source of aggregate and chemical grade (high-calcium) limestone in southern Illinois. Approximately 850 feet of core were logged.

### Silica and Industrial Sand

**Geology of Microcrystalline Silica (Tripoli) Deposits in Southwestern Illinois,** *R. B. Berg and Masters* Dr. Richard B. Berg of the Montana Bureau of Mines and Geology, visiting geologist in the Industrial Minerals and Metals Section, returned to Butte in September 1990. While in Illinois, Dr. Berg was engaged in field mapping and research related to the distribution, character, and origin of microcrystalline silica (tripoli) in Alexander and Union Counties.

An extensive report that includes a detailed map of a 3-square-mile area west of Elco in Alexander County, description of more than 100 mines and prospects, and the results of mineralogical, chemical and petrographic studies was completed. Field work indicated that a prominent chert bed at the top of the Clear Creek Chert can be widely recognized and used as a guide to underlying microcrystalline silica. Study of fluid inclusions in minute quartz crystals that occur in prominent clay bands in the microcrystalline silica indicate that, in addition to in situ weathering, low-temperature hydrothermal fluids played an important role in the formation of these deposits.

### Clay Mineralogy and Clay Resources

**Clay Mineral Business,** *Hughes, Moore, White* Support of clay-mineral-based industrial activity in Illinois included consultations, analysis of samples, phone conversations, and the assembling and sending of operation-related data. Recent efforts have focussed on continued support for the establishment of new mines and plants and the possibility of exploiting low-quality natural gas resources from coal beds for the production of fired-clay products.

**Occurrence of Kaolin in the Neda Formation,** *Hughes and Moore* Potentially valuable kaolin deposits have been located within the Neda Member of the Maquoketa Group. The task of digitizing existing data and searching well logs for possible new occurrences has begun. Two localities have been identified recently. A public release of information is planned for June 1992.

**Alteration of Clay Minerals from Shale of the Davis Formation, Southeast Missouri,** *Panno* The objective of this research was to evaluate the alteration of clay minerals extracted from shale overlying an ore deposit of the Mississippi Valley type. Shale samples were collected, and clay minerals were separated from the samples and analyzed using X-ray diffraction. Results indicate that the illite crystallinity index is altered within several kilometers of the ore deposits. The distribution of the illite crystallinity indices and elemental potassium in the shale provide evidence for a temporal framework in which to place major hydrothermal events in the southeast Missouri lead district.

### Fluorspar and Metal Resources

**Intrusive Breccias at Hicks Dome, Hardin County, Illinois,** *Bradbury and Baxter* Hicks Dome, located in extreme southern Illinois, is a circular, uplifted structure marked by numerous occurrences of intrusive breccia. Intrusive breccias at Hicks Dome are believed to have been formed by explosive release of gases from a deeply buried alkalic magma, a mechanism also responsible for approximately 4,000 feet of uplift related to the dome. Forty-five breccias bodies have been mapped in the immediate vicinity of Hicks Dome. Most are nearly vertical breccia dikes up to 10 feet wide; some are bodies of undetermined shape. Some breccia exposures are mineralized, and mineralized breccia (F, Pb, Zn, Ba, Nb, Be, Ti, Th, and REE) are known to occur at depth. The area was recently drilled and explored by American Smelting and Refining Company (ASARCO). A report that describes the geology, chemistry, and mineralogy of these breccia bodies and the relationship of Hicks Dome to alkalic igneous activity associated with the Reelfoot Rift-Rough Creek Graben has been completed.

### Beneficiation/Processing

**AKBAR Grinding Process,** *Khan, Richter, Witzany, Baxter (ISGS); Gurmen (UIUC)* The proprietary advanced, kinetically balanced and rocking (AKBAR) grinding process is being developed at the ISGS to save energy lost to nonproductive work during grinding. Comminution tests were carried out with a computerized lab-scale grinding mill designed to operate in the proposed AKBAR mode and in a conventional tumbling mode. Equal-energy grinding comparison tests of the AKBAR roller-mode operation versus conventional rotating-mode operation indicated the AKBAR roller-mode operation was somewhat more efficient for larger size (-1500μ) products but less efficient for smaller size (-75μ) products. Similar tests of the AKBAR ball-mode operation versus conventional rotating-mode operation indicated the AKBAR ball-mode operation was somewhat more efficient for both large and small particle-size products. A patent disclosure of the AKBAR process has been reviewed by the ISGS Patent Committee.

### Technology Transfer and Information Services

**Minerals Industry Map of Illinois,** *Baxter, Masters, McKay, staff* The Minerals Industry Map of Illinois (1:500,000 scale), now out of print, shows oil fields and coal mines; nonfuel mines, pits, and quarries; and mineral-processing plants. It also shows the state network of railroads and pipelines. During the last several years, during various ISGS projects, much of the data necessary to updated the map has been compiled in digital form. An ad hoc subcommittee of the ISGS Mapping Committee is now being formed to review the existing data, determine what work remains to be done and to plan for the new edition.

**Industrial Minerals and Metals Publications of the ISGS through December 1989,** *Goodwin, Mikulic, Baxter* An annotated bibliography of ISGS Publications, an expansion and update of ISGS Illinois Mineral Notes 69, was published during the year. Publications are listed alphabetically by commodity. The bibliography, more comprehensive than past listings, was expanded to include publications of a general nature. Many new listings deal with details of stratigraphy, depositional environments, and geochemistry of Illinois rocks—subjects of growing importance in the exploration for mineral deposits.

**Exploration Activities in Illinois, 1990,** *Masters, Frankie, Hughes* The ISGS provides a brief summary of exploration activities for the review issue of *Mining Engineering*, a periodical published monthly by the Society of Mining, Metallurgy, and Exploration (SME). Highlights of exploration for coal, fluorspar, crushed stone, natural sands and gravels, tripoli, and clays in Illinois during the calendar year 1990 were summarized in the May 1991 issue.

**Midcontinent Industrial Minerals Workshop: Working to Ensure the Availability of Constructional Materials,** *Leighton, Eidel, Baxter, Bhagwat, Mikulic* With the cooperation of the U.S. Bureau of Mines and nine states (Arkansas, Iowa, Illinois, Kansas, Kentucky, Missouri, Nebraska, Oklahoma, Tennessee), the USGS will sponsor an industrial minerals workshop in St. Louis, Missouri, September 16 and 17, 1991. Invited participants will represent a broad spectrum of public and private interests: explorationists, county and regional planners, users, and state and local regulators. Representatives of IDOT, IDMM, IEPA, and ENR will participate. The major thrust will be to address the availability of adequate aggregate materials required for construction and rehabilitation of infrastructure, particularly in and adjacent to metropolitan areas, in an environmentally sensitive manner. The ISGS has worked closely with the USGS and IDMM to plan the workshop, identify potential participants, speakers, and panel members.

## MINERAL ECONOMICS

### Applied Economic Research

**Economics of the CO-Ethanol Coal Desulfurization Processes**, *Goheen, Joshi, Bhagwat* Preliminary economic estimates of the concept of a three-step batch desulfurization of coal using carbon monoxide and ethanol were made by Schaschwary and Bhagwat in 1989. Experiments on a 1 lb/hr continuous flow unit were conducted during 1990. As a result of these experiments, the economics of the three-step process were reexamined. The revised flowsheet of the three-step process replaces the rotary kiln reactor with the fluidized-bed reactor to reflect the reality in the laboratory experiments. Additional results to confirm the stipulated 90-percent sulfur removal could not be obtained. Therefore, the economic estimates remain conceptual as in the 1989 report by Schaschwary and Bhagwat. With the change in the flowsheet, the total required capital investment for a 1000 tons/day conceptual plant was estimated to be about $55 million, and the breakeven price of the coal-like product (90 percent desulfurized) would be about $55 per ton.

To simplify the process and reduce costs, the principal investigators developed a one-step desulfurization concept. Work on a conceptual one-step process continues as required by the contract agreement.

### Technology Transfer and Information Services

**Illinois Mineral Industry in 1988 and Review of Preliminary Mineral Production Data for 1989,** *Samson and Bhagwat* The study was summarized in the annual report for July 1989 to June 1990. The final edited version of the report has been published in the ISGS publications series Illinois Minerals 105.

**Illinois Mineral Industry in 1989 and Review of Preliminary Mineral Production Data for 1990,** *Samson and Bhagwat* Data collection for 1989 has been completed. The value of minerals extracted in 1989 was 2.0 percent higher than in 1988. Although coal production increased by 0.5 percent, the per ton value declined by 1.3 percent. Conversely, oil production in 1989 declined 9.3 percent while the price increased from $14.80 to $18.68 per barrel. Production of industrial and construction minerals increased by 4.4 percent without significant price change per ton. Preliminary 1990 production and value data indicate a further 6-percent increase in total value of extracted minerals, despite a decline by 2 percent in oil production. Oil prices increased once more in 1990 to about $23 per barrel, about 20 percent higher than in 1989, mainly as a result of the Persian Gulf crisis. Coal production in 1990 increased by 2.5 percent, although prices were unchanged from the previous year. Industrial and construction materials production also increased in 1990, stone production by 5 percent, and sand and gravel by 2 percent. The report will be published in the ISGS Illinois Minerals series.

A



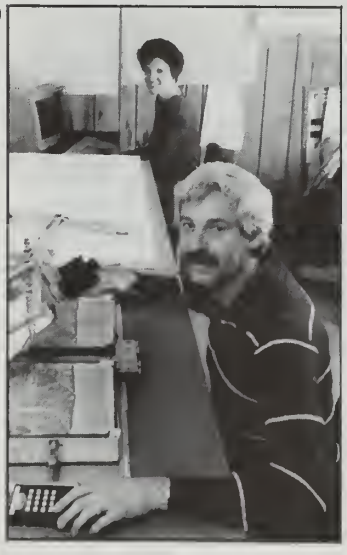
B



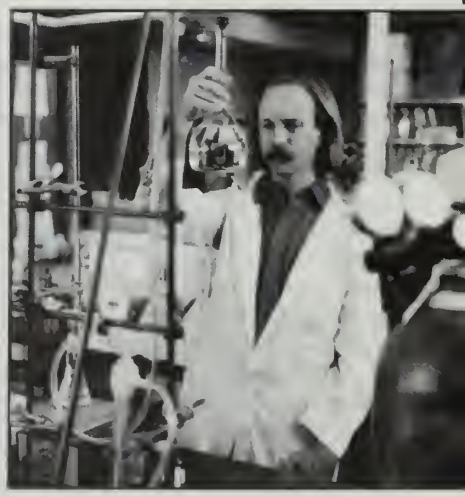
C



D



(A) A drilling crew works in a field south of Champaign to install monitoring wells near the Embarras River for a study of the subsurface movement of atrazine into the river. (B) The Environmental Assessment Section participates in a training session on logging techniques at a drill site in southern Illinois. (C) A miniature well point probe is lowered into the ground for soil gas sampling. (D) Chris Stohr, Earth Hazards/Engineering Geology, uses stereoscopic aerial photographs and a specially adapted stereo plotter to create accurate maps, while geologist Christine Fucciolo works at the computer. (E) Geochemist Bill Roy examines a sample as part of a study on the adsorption of pesticides by soil.

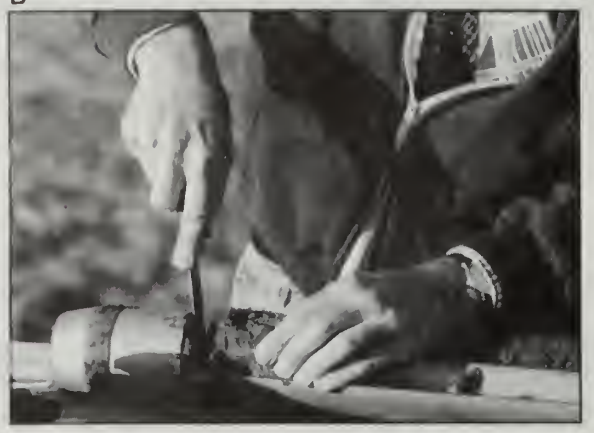


# Environmental Geology and Geochemistry Research and Service

A



B

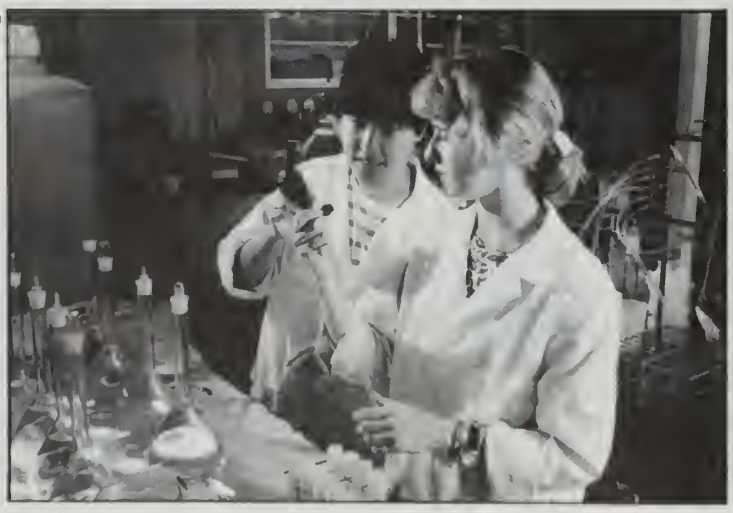


C



(A) Mark Hart (left) and Bill Dixon take soil samples for environmental assessment at an Illinois Department of Transportation project site. (B) Dennis McKenna, Groundwater Protection, removes a core sample from the Embarras River site for laboratory study. (C) ISGS geologist Michael Chrzastowski and engineers for the city of Lake Forest watch as sand is dumped on the south side of Forest Park Beach in Lake Forest as part of a monitoring program on lake bottom changes. (D) Zhenkun Zhao, Geochemistry Section, demonstrates proper pipetting technique to her assistant Lettie Schmitt. (E) A starter tunnel for assembling machines at the Tunnel and Reservoir Project (TARP) in Chicago.

D



E



## ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY

Environmental geology and geochemistry provides service to the public, other state and federal agencies, and industry. Because geologic and geochemical information is used to make policy decisions, it must be accurate, timely, and above all credible. Illinois State Geological Survey information is becoming increasingly important for decisions about hazardous waste contamination, problems caused by disposal of wastes, mining, earthquake risk, property assessments, and other environmental issues.

Current research includes development of new techniques to gather, analyze, and interpret geological and geochemical information. New methods of analysis and testing provide elemental, physical, and dating information, while new computer techniques allow better manipulation and comparison of information. New equipment and techniques enable ISGS geologists and geochemists to gather more field information in less time. All these factors enhance the need for well defined quality assurance and quality control.

For environmental information to be of value to the decision maker it must be understandable and credible. A major effort of the Environmental Geology and Geochemistry Branch is centered on developing means to build confidence with decision makers. Interacting with county officials, providing information to state task forces, participating in hearings, and communicating directly with those needing ISGS information are examples of ISGS activities. Testimony on the proposed low-level nuclear waste facility site investigation, participation in the Federal Emergency Management Administration multi-state earthquake exercise, development of, and continued research in the areas of groundwater protection, pesticide contamination, and wetlands and site assessments for the Illinois Departments of Agriculture, Transportation, and Emergency Services and Disaster Agency, and for other government agencies are examples of the ISGS involvement.

### ENVIRONMENTAL STUDIES AND ASSESSMENT

The Environmental Assessment program is a multifaceted program to provide information on the geologic character and capacity of geologic materials to support specific uses of the landscape. ISGS scientific staff collect new data, correlate previous data and findings, and develop interpretations useful to federal, state, and local agencies and private industry for land-use planning. The dynamic nature of the modern landscape requires an ongoing evaluation through environmental impact studies, facility location screenings, and land-use analyses, so that informed decisions on environmental management can be made. During the past year, the Illinois Department of Transportation Preliminary Environmental Property Assessment Program was expanded to include studies of impacts to geologic systems, especially wetland areas; the Lands Unsuitable for Mining Program (LUMP) sponsored by the Office of Surface Mining and the Illinois Department of Mines and Minerals continued; and completion of several publications reflecting data collected during the Superconducting Super Collider (SSC) site investigation.

#### Special Siting Studies

**Value-Added Effort In Conclusion of the Superconducting Super Collider (SSC) Program,** *Gross, Kempton, Schneider, others* Review and production of publications developed during the SSC investigation continued as anticipated. Reports published during the past year included:

- Illinois Minerals 106, *Cross Section of the Paleozoic Rocks of Northeastern Illinois: Implications for Subsurface Aggregate Mining* includes a geologic cross section between the proposed SSC site and Chicago, and a short report. Additionally, the report includes an assessment for subsurface aggregate recovery, an important resource for the area.

- Environmental Geology 136, *Seismic Reflection and Seismic Refraction Surveying in Northeastern Illinois*, a comprehensive report of the seismic exploration conducted during the SSC investigation, provides subsurface information beneficial for all of northeastern Illinois. Reflection profiling was used to develop an understanding of stratigraphic and structural relations; refraction profiling provided data useful in improving the understanding of bedrock topography and geology, which aids in the development of geologic resources and the environmental management of those resources.

- Environmental Geology 139, *Geotechnical Properties of Selected Pleistocene, Silurian, and Ordovician Deposits of Northeastern Illinois* was the final product for SSC wrap-up task 103. This publication summarizes geotechnical and stratigraphic data collected during the SSC siting study; it provides useful information for future construction in glacial and bedrock materials in northeastern Illinois.

Six open file maps (digital maps), at 1:62,500 scale and showing the character and distribution of various aspects of the geology of Kane County, were completed. These include

- *Bedrock Topography of Kane County*
- *Drift Thickness of Kane County*
- *Earth Materials of Kane County*
- *Soil Drainage Characteristics of Kane County*
- *Distribution and Thickness of the Tiskilwa Till in Kane County*
- *Stack-Unit Map of Kane County (to a Depth of 50 Feet)*

Three open file reports were also completed during this period: *Kane County Water Well Database*, *Quaternary Stratigraphic Control*, and *SSC Bibliography and Archival Listing*. Four additional products are currently in review and will be released during the next fiscal year.

### Environmental Impact Studies

**Environmental Property Assessments for the Illinois Department of Transportation (IDOT),** *Bauer, Schneider, Bannon, Erdmann, Summers, Barclift, Bauer, Carlisle, Dixon, Hart, Morse, Read, Rimmer, Swick, Torzynski, Trask, Trent* The second year of this major statewide environmental property assessment program for IDOT resulted in the completion of more than 130 reports representing 385 miles of state highway projects. The program includes an investigation of historical material to discover the nature of previous land use and onsite investigation to determine the present environmental condition of the property to be acquired by IDOT. Field methods and instruments are used to analyze soil, water, and air for hazardous components. The project will now move toward establishing a comprehensive digital database which will reflect information gathered by project geologists and historical researchers.

**Illinois Lands Unsuitable For Mining Program (LUMP),** *Pool, Taylor, McKay, L. Smith, Stiff, Witzany* The Lands Unsuitable for Mining Program is funded by the U.S. Office of Surface Mining (OSM) through the Illinois Department of Mines and Minerals (DMM). The program objectives are (1) the preparation of land reports in response to a Lands Unsuitable for Mining petition, which address the impacts of surface coal mining on natural resources and (2) the development and maintenance of a detailed GIS database of coal mine permit areas that assists the DMM with its Mine Permit Review program.

The Mine Permit Review (MPR) database effort focused on updating existing GIS reclamation coverages to reflect permit soil capabilities and entering affected acreage and bond release information. ISGS staff worked closely with DMM staff to develop and refine a digital format for the affected acreage and bond release information. Staff also continue to manage the MPR database and coordinate the project activities of all divisions of ENR.

**Proposed Amended Land and Resource Management Plan and Supplemental Draft Environmental Impact Statement (EIS) for the Shawnee National Forest,** *Baxter, Berg, Crockett, Eidel, Damberger, Larson, Oltz, Reed* The proposed amended 10-year management plan for the Shawnee National Forest was prepared in response to appeals filed by various interest groups to the original plan, and incorporates various compromises agreed to in a series of mediation sessions involving a wide cross section of forest interests. The amended plan and EIS were received for our review and comments in May. ISGS comments and suggestions regarding mineral activity and water resources were compiled for transmittal to the U.S. Forest Service by August 15, 1991.

## GEOLOGY FOR PLANNING

The Geology for Planning program operates to conduct geologic and hydrogeologic investigations at the county level. These studies focus on resource identification and provide guidance for environmental management of county resources as local officials plan for the economic health of the community. The studies may vary in scope, depending on the particular needs of the county, but they provide natural resource information at a resolution most useful for county land-use planners.

### County Regional Studies

**Kane County: Resource-Based Land-use Planning,** *Schneider, Trask, Erdmann, Read* Field work was completed this spring. Data from well logs in an eight township study area in the north and west section of the county were reviewed, annotated, and analyzed using GIS techniques. Initial map products, now in review, show the distribution of geologic materials above the bedrock important to various uses of the landscape.

**County GIS Screening for Landfill Siting,** *McKay, Krumm, Abert, McLean, Riggs* The County GIS Screening for Landfill Siting program, funded by the ENR Office of Recycling and Waste Reduction, was established to provide assistance to county governments in the form of maps and other information that can be used during the landfill screening process. This project uses Geographic Information System (GIS) technology and other computer software to compile detailed geologic information and produce maps that can be used by counties for environmental screening. The maps show such features as bedrock topography, the thickness of glacial drift, and sand and gravel thickness. In addition, 'slice maps' are produced to show the lithology of the glacial deposits within a given depth range (i.e., 50 to 100 feet below ground surface). The information generated by the geologic mapping effort is used with other information compiled by the ENR Office of Research and Planning (ORP). During the past year, project staff have met with representatives from Lake, Kankakee, Will, and McLean Counties to discuss the GIS mapping efforts provided by ENR. The work accomplished in Lake and Will Counties is reported separately under "Landfill Siting."

## LAKE MICHIGAN COAST AND BASIN STUDIES

Illinois State Geological Survey staff continue their investigations along the Illinois shore of Lake Michigan. This effort continues to provide detailed information on the character of dynamic coastline features and the interaction of geologic processes and man-made structures. These studies include collaborative work with the U.S. Geological Survey (USGS), Indiana Geological Survey, and coastal researchers from Northeastern Illinois University, Purdue University, and Indiana University. These research activities have been supported mainly through an agreement with the USGS. Additional funding has been obtained from the Federal Emergency Management Agency (FEMA), Illinois Department of Conservation, and Illinois Department of Transportation (IDOT).

The coastal area of southern Lake Michigan is relatively unique in that many of the deleterious effects of lake dynamics are focused along one of the most populated and developed shorelines of the Great Lakes. Because of the more than 300 miles of fetch from north to south, there is high probability for maximum wave energy to be expended along the Illinois' shore. The potential for adverse impact to beaches, bluffs, coastal defense structures, and other coastal development makes it imperative that the ISGS continue a coastal research program. This research, important for providing necessary information to local, state, and federal agencies, as well as the private sector, will allow for the implementation of policy for coastal development and the mitigation of impacts.

**Monitoring of Lake-Bottom Changes in the Vicinity of North Point Marina,** *Chrzastowski, Terpstra, Fucciolo, Jennings, Horstman, Miner* The Lake Michigan shore near the state-owned North Point Marina continues to adjust to the importation of sediment and the introduction of structures related to the construction of this facility. Through winter and spring 1991, monitoring of the rate of erosion along a sacrificial sand reservoir near the marina continued. This reservoir provides sand nourishment to the shore of the adjacent Illinois Beach State Park. Monitoring also continued to allow evaluation of interim shore defenses now protecting a marina parking facility. This facility was previously endangered by the development of approximately 200 feet of erosion, which occurred in only 10 months of the proceeding year. In June 1991, the fourth in a series of annual bathymetric surveys was conducted to update the database for lake-bottom areal and volumetric change.

**Coastal Monitoring at Forest Park Beach,** *Chrzastowski, Trask, Van Roosendaal* The state-of-the-art coastal engineering and coastal development project built by the City of Lake Forest at Forest Park Beach requires beach and nearshore coastal monitoring to identify any adverse impacts so that mitigation, if necessary, can be planned and implemented. In 1991 the City of Lake Forest began a new five-year monitoring program near Forest Park Beach. Concurrently, the ISGS began collecting beach- and hydrographic-survey data and overseeing quality assurance and quality control for the city monitoring effort. This project, funded by the Illinois Department of Transportation, Division of Water Resources, will continue through the next year.

**Olson Site: Submerged Forest Research,** *Chrzastowski (ISGS), Folger and Foster (USGS), Pranschki and Shabica (Northeastern Illinois University)* During late summer and early fall 1990, processing of seismic reflection data previously collected at the Olson site of 8,300-year-old submerged tree stumps, revealed a complex pattern of buried stream channels incised as much as 6 meters into the sub-bottom glacial till. These data, combined with limited core data and sidescan-sonar imagery, strongly suggest that the paleoenvironment of this ancient forest was a floodplain setting. The age and elevation of the

tree stumps are being used in a reevaluation of early to mid Holocene lake-level history for southern Lake Michigan.

**Southern Lake Michigan Coastal Evolution,** *Chrzastowski (ISGS); Thompson (IGS)* A cooperative study by coastal geologists at the ISGS and Indiana Geological Survey is examining the evolution of the modern and ancient shorelines of southern Lake Michigan during the past 14,000 radiocarbon years. This is one of the framework studies of the ongoing USGS cooperative projects in the Great Lakes. Sediment cores have been collected at several select sites to provide new radiocarbon-age control on relict spits and barriers near the Illinois-Indiana state line. The geomorphology of several relict spits were examined for possible trends in lake-level change in the early history of ancestral Lake Michigan. This study led to a process geomorphic model for the late Holocene evolution of the Chicago River, and the identification of major coastal erosion zones during the past 3000 years along the Chicago area lakeshore and the lakeshore near Calumet Harbor.

### Lake Michigan Database Development

**Photographic Documentation of Lake Michigan Shoreline Changes,** *Jennings, Terpstra, Su* More than 1,000 color transparencies were added to the ISGS shoreline documentation library during December 1990. These have been useful for replies to individuals and companies requesting information on the status of the Illinois Lake Michigan shoreline, as well as for supplying basic data to scientific researchers.

### Coastal Erosion Studies

**FEMA—Lake Michigan Shoreline Erosion,** *Jennings, Eng, Sena, Stohr* A new initiative for estimating the erosion rates along the Lake Michigan shoreline has been made possible by a $62,000 grant from the Federal Emergency Management Administration (FEMA). This work uses historical data and begins with making very accurate measurements of the location of nearshore features. These features are used as control points to orient maps or pairs of aerial photographs using a stereoplotter. The stereoplotter has been configured to input spatial data directly into a digital system at accuracies previously unobtainable at the ISGS. This system has been used to determine the position of whatever shoreline and bluff line is illustrated, and will ultimately show a minimum of four historical shorelines. Control points have been established for Waukegan, Fort Sheridan, and Highland Park. Digitization of a recent shoreline in Highland Park has been completed and digitization will be done for the remainder of Lake County as the project progresses.

### Lake History Studies

**Lake Michigan Littoral Zone Classification and Mapping** On July 1, 1990, a new 2-year program was funded by the U.S. Fish and Wildlife Service and administered by the Illinois Department of Conservation (IDOC). The program provides basic maps of shore culture, bathymetry, and surficial bottom materials (including reefs) of the harbors and the lake. This information will provide IDOC with valuable information necessary to manage the Illinois Lake Michigan fisheries. The collection of bathymetric data for all the harbors—North Point Marina, lakeshore from North Lincoln Park to Loyola University, and Chicago Outer Harbor and vicinity—were supported by USGS. This information is being augmented with more bathymetry along the coast and bottom sediments interpreted from sonar and direct sampling of sediments. IDOC also has requested that the Silurian reef locations in Lake Michigan be updated, since there is a recent revival of interest by lake trout fishery specialists.

**Bathymetric Mapping, Bottom Sampling, and Land Surveys,** *Fucciolo, Miner, W. Mehnert, Collinson, Lambert, Horstman, Jennings, Matthews* Bathymetric data were collected for a 4½-mile stretch of the Chicago Lake Michigan shore. Surveying extended from the Montrose-Wilson Groin in Chicago to Keeney Street in Evanston. Seventy-two, nearshore, east-west depth profiles were run from the shoreline to approximately 1½ miles offshore. Shore station locations and shoreline positions were mapped as well. Bathymetric contour maps for the nearshore zones for north Lincoln Park and the Edgewater District were produced by reducing the collected data to a standard datum plane, and by plotting, contouring, and digitizing it to produce a one-foot contour interval map.

The USGS supported lake bottom surveying of 29 depth profiles performed on Lake Michigan in Chicago Outer Harbor and south of Burnham Park Harbor. These profiles were used to complete a 1-foot bathymetric contour map encompassing 4 miles of shore from Division Street to 24th Street, extending 5,000 to 6,000 feet offshore.

Bottom materials in five small-boat harbors were sampled with a petite Ponar grab sampler. Sampling was performed in Montrose, Belmont, Diversey, 59th Street, and Jackson Park Harbors. Sediment samples were also collected in the nearshore areas between north Lincoln Park and Loyola Park. Sediment samples were microscopically analyzed for grain sizes and plant and animal remains. In addition to confirming the position of the sand/till boundary, grab sampling was used to map the areal extent of boulders, gravel, sand, silt, and clay. Color-coded distribution maps detailing the areal extent of boulders, gravel, sand, silt, clay, and glacial till in bottom materials will be prepared for each harbor, north Lincoln Park, and the Edgewater District. A 1:24,000-scale map of the location and extent of the lakeward edge of the littoral sand apron, offshore of Illinois Beach State Park, was also produced from existing ISGS work.

In 1979 ISGS published information on the distribution of Silurian bedrock reefs in southern Lake Michigan for the Illinois Coastal Zone Management Development Project. Since then additional reefs have been found and more can be identified through ISGS geophysical data, which has not been interpreted yet. A 120,000 scale map has been produced showing all of the previously published reefs as well as newly identified ones.

Land base maps were updated as well. The Lincoln Park map extends from Gorden Terrace to the Foster Avenue Groin. It includes Montrose Harbor, the Montrose-Wilson Groin/Fishing Pier, and Montrose-Wilson Beach. Extending to West Sheridan Road, the Edgewater District map includes Foster & Hollywood Avenue Beaches. Both maps show features along 1½ miles of shore and water depths from the shoreline to approximately 1 mile offshore.

**Zebra Mussels in Chicago Harbors and Nearshore Areas,** *Fucciolo, Miner, Lambert* During sediment sampling for the IDOC contract, a major discovery was made—zebra mussels—the first time zebra mussels had been found in Chicago's small-boat harbors. Several zebra mussels were collected on a gravel bed that extends from the outer to the inner Jackson Harbors. Zebra Mussels are an exotic European species introduced into the Great Lakes in 1986, where they have spread widely and rapidly. They are a severe nuisance to humans as well as a threat to the ecology of Lake Michigan. They clog water intake pipes and foul boat bottoms and motors, commercial fishing nets, as well as foul spawning areas and recreational beaches. Shortly after the initial siting, zebra mussels were also discovered on gravel beds just inside the mouth of 59th Street Harbor and just outside the mouth of Diversey Harbor. These populations apparently are the colonizers of the Chicago shore areas. Late in June, zebra mussels were discovered 4,000 feet east-southeast of the mouth of Montrose Harbor, in 22 feet of water. The discoveries were promptly reported to the IDOC Lake Michigan Chicago Office, the zebra mussel watch officer of the State Natural History Survey, and the Illinois-Indiana Sea Grant Office in Oak Brook. Maps showing sites were also forwarded.

## WETLANDS, RIVERS, AND INTERIOR LAKES

As expected, concern over the preservation of wetlands and the quest to better quantify wetland functions and values increased during this report year and Survey staff continue efforts to more adequately understand the geologic processes important to wetland restoration, maintenance, and preservation. The riverine, lacustrine, and coastal systems associated with wetlands are inextricably intertwined both above the landscape and beneath it. The present focus on wetland preservation by many elements of government has resulted in a need for a better definition of wetlands in the context of regulatory delineation. ISGS entered into an agreement to assist the Illinois Department of Transportation in developing basic geologic information for mitigation plans and monitoring potential impacts to wetland mitigation resulting from highway projects. Other wetland and riverine system projects, such as the extensive Des Plaines River project in Lake County, continue to be studied by the ISGS and affiliate agency staff.

**Geochemistry of Sediments In the Grand Calumet River,** *Cahill, Henderson, Steele, R. Frost, Liu* The west branch of the Grand Calumet River is located in northwestern Illinois. The west branch is about 6 miles long and is located in an intensely industrialized area. The flow is generally low (one to two feet per second) and to the west. Sediment accumulation rates and quality were measured by the ISGS at nine locations to provide information for proposed environmental cleanup efforts in the area. Sedimentation rates, determined by cesium-137 dating, ranged from <0.1 to 5.8 cm/y. Concentrations of organic carbon, and 25 elements were determined. In general, the highest concentrations of metals

are in the Indiana section of the river in sediments that were deposited in the 1950's. A final report was completed, additional funding is being sought, and a journal article is planned.

**Geochemistry of Sediments in the Cache River Wetlands,** *Cahill (ISGS); Demissie (ISWS); Fitzpatrick (ISWS)* The Cache River wetland is located in the extreme southern part of Illinois and is one of the more important natural wetland areas in the state. One of the major problems in the wetland is the accumulation of sediments in ecologically sensitive areas. Sediment cores were collected at ten locations and sedimentation rates were determined by cesium-137 analysis. Results were compared with sedimen-tation rates determined by monitoring sediment flowing into and out of the wetlands for four years at six stations. The two techniques gave consistent results, the cesium-137 technique gave site specific results, while the monitoring procedure gave an average accumulation over a wider area for a fixed time interval. A manuscript was prepared, and is undergoing peer review at the Illinois State Water Survey for submittal to the journal, *Water Resources Research.*

**Investigation of thePotential Impact of a Proposed Highway Drainage System on the Wetland in the Black Partridge Forest Preserve, Cook County**, *Hensel, Cartwright, Barnhardt, Hansel* This investigation, funded by the Illinois Department of Transportation (IDOT), centers on a spring in the Black Partridge Forest Preserve. IDOT is concerned that the drainage system of proposed FAP 431 may divert groundwater recharge from the local groundwater flow system, causing the spring and associated wetland area to dry up. The highway will be located in the spring's recharge area, and a loss of recharge water via the drains is likely. The purpose of this investigation is to determine the impact of the loss of recharge on the spring and wetland.

The project was initiated during spring 1991. The first stage of the investigation, site hydrogeology, is underway. Seven boreholes have been drilled, and a piezometer has been installed in each. Geologic data have been gathered from the boreholes. Water-level and hydraulic conductivity information will be collected from the piezometers.

These data will be used in a numerical groundwater flow model. Once the model is calibrated to current conditions, a set of drains will be simulated to observe any possible effects that the loss of recharge water may have on the springs.

**Wetlands, Demonstration Project along the Des Plaines River in Lake County, Illinois,** *Miller, Hensel, Rhoads* The project as reported in the 89-90 Board Report has been extended through September 30, 1991. Four experimental wetland areas (EWA) are being investigated at the demonstration site. One of the major purposes of the project is to purify river water which is supplied by pumps.

The project is currently divided into two phases including river channel geomorphology and groundwater. The river channel geomorphology phase of the project utilizes 28 channel cross-section sites to assess the long term effects of wetland construction and operation on the stability of the channel. Cross section measurements are made once a year (July) and compared to previous measurements for change and pattern of change. Fourteen erosion grid sites were established during 1989-90 to assess floodplain erosion/deposition, and re-surveyed during October 1990 to note change. These data are currently being analyzed for change.

Groundwater is investigated using a well network of 76 piezometers and observation wells established in 1987. These instruments assess the effect that the operation of the constructed experimental wetland areas (EWA) has on the local water table and the established groundwater movement pattern. Results indicate that the net movement of water of two EWQ ponds recharge the groundwater, and two ponds receive a small net discharge of groundwater. Current activities include estimating groundwater interchange with the EWAs and further calibrating the flow model being used to show effects. Renewed construction at the site during the summer of 1991 will necessitate additional well sites and erosion grid sites to encompass this change to the site.

## GROUNDWATER PROTECTION

The Groundwater Protection Act calls for (1) developing a coordinated groundwater data collection and automation system that includes the results of groundwater monitoring and the collection of well logs, pollution source permits, and water quality assessments; (2) developing and administering an ongoing program of basic and applied research; and (3) making the results and information available to local

governments seeking assistance. The research program will focus on (1) long-term statewide groundwater monitoring; (2) statewide groundwater assessments on groundwater resources that will enhance the database by locating groundwater resources, mapping aquifers, identifying appropriate rechrage areas, and evaluating baseline water quality; (3) evaluating pesticide impacts on groundwater; and (4) other basic and applied research including groundwater hydrology and hydraulics, movements of contaminants, and aquifer restoration and remediation technologies. The effort is to be carried out by the Department of Energy and Natural Resources; however, the Act was not fully funded.

Within existing appropriation under the limited General Revenue Funds, allocations under the Hazardous Waste Research Fund, and contract funds, the Illinois State Geological Survey is focusing its efforts on technical assistance for determining pesticide impacts on groundwater and for groundwater assessment.

**Technical Assistance**

**Groundwater Protection Needs Assessment for Woodstock, Illinois,** *Berg, Mushrush, Keefer* As a pilot study to determine the methodology to be used in assisting local governments, Woodstock, Illinois was selected by the ISGS and ISWS in cooperation with the IEPA to conduct the geologic and hydrologic aspects of a needs assessment. This involved detailed geologic and hydrologic mapping for the entire Woodstock 7-1/2 minute topographic quadrangle to define areas of potential contamination and evaluate aquifer characteristics. Preliminary cross sections have been completed, as well as isopach maps of the four aquifers that were discovered in the area, a stack-unit map of materials to a depth of 100 feet, and an aquifer contamination potential map.

**Geologic Framework for Determining Underground Sources of Drinking Water Requiring Protection,** *Herzog, Berggren, Brower, Chenoweth, Graese, Jacobson, Poole, P. Reed, E. Smith, Shaw, C. Treworgy, J. Treworgy, Vaiden, Weibel* The third phase of this project began in August 1989 at the request of the Illinois Department of Mines and Minerals (IDMM), which initially funded the project. The project was completed in March 1991. The EPA has determined that groundwater is unfit for human consumption if the total dissolved solids content is greater than 10,000 parts per million (ppm). According to law, oil and gas wells must be cased through potential drinking water supplies.

One hundred fifty east-west and north-south cross sections illustrating the relationship between stratigraphy and estimated water quality were prepared for 19 oil-producing counties. Sandstone bodies with less than 10,000 ppm were identified on these sections to the best of our ability. Reports and cross sections have been delivered to IDMM for Bond, Clark, Clinton, Cumberland, Edwards, Effingham, Fayette, Franklin, Gallatin, Hamilton, Jasper, Jefferson, Marion, Richland, Saline, Washington, Wayne, White, and Williamson Counties. Ten individual cross sections, with reports, were completed and delivered for areas surrounding the main oil-producing portion of the Illinois Basin.

IDMM is using the cross sections and resulting data to determine casing depths so that potential water supplies can be protected.

**Development of Maps of Karstic Areas of Monroe, ST. Clair, and Randolph Counties: Groundwater Protection,** *Panno* Maps of the karstic regions of Monroe, St. Clair, and Randolph Counties in southwestern Illinois are being developed to determine the areas of these counties that are most susceptible to groundwater contamination. The maps are a preliminary step of a demonstration project that is being developed by the Mississippi Karst Resource Planning Committee. The demonstration project is being designed to minimize contamination to the unconfined aquifer by agricultural pollutants in the three-county area. The maps will identify drainage basins, bedrock lithologies, geomorphologic indicators, and thickness of overburden.

**Pesticides in Groundwater**

**Pilot Study—Agricultural Chemicals in Rural, Private Water Wells,** *E. Mehnert, Dreher, Barnhardt, S.-F. Chou, Dey, Valkenburg, Greenpool* The ISGS and the ISWS are currently conducting a pilot study, in cooperation with the Illinois Department of Agriculture, to field test and evaluate various components of the experimental design of a proposed statewide survey described in Cooperative Groundwater Report 11. In addition, the pilot study will provide a preliminary assessment of the occurrences of agricultural chemicals in rural, private wells in five, representative hydrogeologic settings in Illinois. The research is funded by the Illinois Environmental Protection Agency and the Illinois Department of Energy and Natural Resources.

Sampling of water wells was completed in February 1991. Sampling and analysis of 240 well-water samples for 39 agricultural chemicals and nitrate and nitrite were completed during the fiscal year. The USEPA National Pesticide Survey (NPS) methods were used to analyze the water samples. The ISGS determined 20 of the compounds using two of the NPS methods. Other compounds were analyzed by the State Water Survey and the Illinois Department of Agriculture. Reports describing the characterization process and the overall project are in preparation. The draft report of characterization was due September 30, 1991; the draft final report is due November 30, 1991.

**Statewide Survey of Agricultural Chemicals in Rural, Private Water-Supply Wells in Illinois,** *McKenna* The ISGS is cooperating with the Illinois Department of Agriculture and the Cooperative Extension Service-University of Illinois at Urbana-Champaign in conducting statewide survey to provide statistically reliable estimates of the occurrence of agricultural chemicals in rural private wells in Illinois. Groundwater samples are being collected from approximately 340 randomly selected wells and analyzed for nitrate, nitrite, and a number of pesticides and metabolites. Sampling began in March 1991 and will continue through March 1992.

**Potential for Agricultural Chemical Contamination of Aquifers in Illinois,** *McKenna and Keefer* In support of the state's Pesticide Management Plan being developed by the Illinois Department of Agriculture, statewide geologic mapping of Illinois is being used to identify regions with aquifers vulnerable to contamination by agricultural chemicals. A state map at a scale of 1:500,000 and a map for each county (1:250,000 scale) are being prepared. Areas with intensive corn and soybean production and aquifer materials within 50 feet of ground surface are most vulnerable to contamination. In approximately 40 percent of rural Illinois, aquifers lie within 50 feet of ground surface. These shallow aquifers occur throughout Illinois but are most common in the northern and southern parts of the state and along the major river valleys. In about 60 percent of rural Illinois, the aquifers are more than 50 feet deep and may be protected from pesticide contamination by the attenuation capacity of soils and thick sequences of fine-grained materials. Pesticide use, largely for corn and soybean production, is heaviest in areas of the state where aquifers appear to be least vulnerable to contamination.

**Groundwater Contributions to Atrazine Loadings in Streams: Adsorption Studies,** *McKenna, Risatti, Roy, E. Mehnert, Krapac* In order to estimate the relative contribution of surface water runoff and shallow groundwater discharge to pesticide loadings in streams, we are investigating the subsurface movement of atrazine and deethylatrazine (DEA), a primary degradation product of atrazine, in a small watershed in East Central Illinois.

Samples of groundwater, tile-drainage water, and stream water were collected three times prior to application of atrazine and six times (biweekly) after application. Screening of water samples with the immunoassay test for triazines indicates that triazines were (1) consistently present in stream samples collected after April 17, (2) present in tile-water samples collected 4 to 10 weeks after application of atrazine, (3) not detected in monitoring wells located in the field downgradient of the application site, and (4) tentatively identified in one groundwater sample collected from a monitoring well installed in the stream bed. Analyses of these samples on the gas chromatograph have not been completed.

The adsorption of atrazine by surface soils is well understood, but there are few studies on the movement of atrazine in deeper low organic carbon (OC) materials. Research to date indicates that the organic carbon-water partition coefficient ($K_{oc}$) of atrazine (between 107 and 160 mL/g) may underestimate the extent of atrazine adsorption by these materials. Laboratory measurements indicated that the extent of atrazine adsorption may be between 1 to 5 times greater than that predicted by the organic carbon content. This observation is consistent with other studies.

Desorption measurements have indicated that after atrazine is adsorbed, it does not desorb readily during short-term (72-hour) intervals. As the organic carbon content increases, the degree of hysteresis (lack of reversibility) also increases. It remains to be determined whether the hysteretic behavior is the result of slow desorption kinetics and/or true chemisorption where atrazine reacts with the organic matter to form chemical bonds. Once atrazine migrates below the surface soil, its subsequent migration will be slightly retarded by adsorptive-desorptive interactions, depending on the distribution of organic matter in the subsurface. Studies with DEA will be started during the next fiscal year. The project was funded by the U.S. Department of Agriculture/Cooperative State Research Service through Southern Illinois University.

**Solid-Phase Extraction for Determination of Pesticide Residues in Groundwater,** *S.-F. Chou, Valkenburg, Dreher* As concern over the contamination of groundwater with pesticides mounts, there has been an increasing public call for efficient groundwater monitoring. The USEPA has developed analytical chemical methods for the National Pesticide Survey (NPS). All methods that use liquid-liquid extraction are fairly cumbersome, use an undesirable solvent, and are time consuming. ISGS staff are trying to eliminate some of the undesirable features of these methods. Solid phase extraction (SPE) provides an excellent means for multiresidue analysis (i.e., analysis of many pesticides). It allows for large (i.e., 1 L or greater) sample volumes to be extracted with a minimum of glassware and organic solvents.

The most important advantage of the SPE is reduced sample preparation and extraction times, with time requirements from one-third to one-half those of liquid-liquid extraction. Preliminary results show that good recoveries for most spiked pesticides were observed. Aldrin, chloramben, and bentazon recoveries were low. Eighty-eight percent and 106% of atrazine and alachlor were recovered from spiked reagent water (0.5 to 1.0 ppm), respectively. In the case of some pesticides, extraction efficiencies are better with SPE than with the liquid-liquid extraction.

**Procedures and Guidelines for Addressing Pesticide Contamination at Agrichemical Facilities in Illinois,** *McKenna, Roy, Herzog, Risatti, Krapac, Barnhardt* The ISGS is assisting the Illinois Department of Agriculture (IDOA) in addressing the 1990 amendments to the Illinois Pesticide Act which require the IDOA to develop guidelines and recommendations regarding long-term financial resources which may be necessary to remediate pesticide contamination at the approximately 1300 agrichemical facilities in Illinois. This project includes (1) developing an initial strategy for conducting assessments of site conditions and operational practices at agrichemical facilities in Illinois; (2) providing a scientifically valid approach to the establishment of soil-trigger levels based on the potential for pesticide transport to groundwater; (3) developing several alternative procedures for sampling plans to collect soil-core samples to determine whether a site is contaminated; and (4) evaluating available remedial technologies appropriate for contaminated agrichemical facility sites and estimating the cost effectiveness of these technologies for site conditions commonly found in Illinois.

The ISGS has completed (1) a review of alternative sampling plans for selecting specific agrichemical facilities for on-site assessments, (2) an initial screening of the potential for aquifer contamination at 60 randomly selected agrichemical facilities based on existing geologic mapping at a scale of 1:250,000, and (3) provided assistance to the IDOA in developing technical standards for conducting phase 1 and phase 2 environmental site assessments at 20 agrichemical facilities. The actual evaluation and assessment of site conditions and operational practices at agrichemical facilities will be conducted by other contractors.

**Drainage Tile Monitoring Study,** *Keefer* This research evaluated the utility of monitoring drainage tile effluent for pesticides as a potential alternative to the installation and monitoring of large networks of groundwater monitoring wells. Samples were collected from drainage tiles, soil water samplers, groundwater monitoring wells, and soil samples. The results from this study demonstrate that pesticide concentrations in drainage tile effluent can be used to evaluate the leaching behavior of these compounds in the field—provided that certain information is known regarding the tile system layout and local hydrogeologic setting. This project was funded by the Water Resources Center at the University of Illinois.

### Groundwater Assessments

**Methodology for the regional assessment of Aquifer Contamination Potential Based on Geologic Framework,** *Soller (USGS, Reston); Berg (ISGS)* The ISGS has cooperated with the USGS to develop a methodology that will assess contamination potential of aquifers on a multistate basis. Information is derived from three-dimensional geologic maps recently produced by the USGS. The texture of surface sediments, permeability of the bedrock directly beneath surficial deposits, presence of aquifers, and thickness of surficial deposits are the four parameters evaluated in this investigation. A method was devised to compare hydrogeologic settings according to relative degrees of susceptibility to potential contamination of aquifers. Results of the investigation were submitted and accepted by a journal for publication. This work was supported by USEPA Region V.

**Potential for Aquifer Recharge in Illinois (Map),** *Keefer and Berg* This map was generated in response to the needs of the Illinois Groundwater Protection Act. The map shows recharge areas based

on depth to aquifers and surface soil infiltration. It can also be used to evaluate contamination potential of aquifers. Not shown on any other published ISGS map is an evaluation and consideration of contamination potential and recharge to deep aquifers.

**Contamination Potential Map of the Chicago 3°x 6° Sheet,** *Soller (USGS); Berg (ISGS)* A contamination potential map of the Chicago 3° x 6° sheet, including parts of Illinois, Indiana, Ohio, Michigan, and Wisconsin, has been produced in a cooperative effort by the USGS and the ISGS using USGS texturally based three-dimensional maps. The validity of information portrayed on this map is currently being statistically evaluated by the USGS by comparing contamination potential units on the map to actual nitrate contamination of wells. The investigation was supported by USEPA Region V efforts to better understand regional contamination potential problems caused by agricultural chemicals.

## WASTE MANAGEMENT

For almost 30 years, the ISGS has conducted a research and service program concerned with waste management issues. This program includes the following primary areas of activity: county assistance to manage solid waste, characterization of candidate low-level radioactive waste sites, hazardous waste disposal issues, and coal waste. County assistance programs attempt to assist local governments in understanding geology and interpreting its complexities for meaningful land-use determinations. Our program on low-level radioactive waste characterization evaluates the process of waste disposal siting and geologic characterization. Research into deep-well injection and coal wastes evaluates the movement of potentially hazardous contaminants in groundwater and the capability to predict and trace contaminant migration.

### Landfill Siting

**Champaign County: Geologic Assistance for Landfill Site Screening,** *McKay, Smith, Panno* Geologic mapping completed in the spring of 1990 has been utilized by the Champaign County Intergovernmental Solid Waste Disposal Association to identify 2 potential landfill sites. Preliminary results from test borings drilled by the county on the sites in the southeastern part of the county indicate that both may be geologically suitable. One site has been selected for detailed site investigation. If the IEPA issues a permit for the site, a landfill will be opened in 1994 or 1995. Results of the ISGS mapping project were a key in the identification of the sites. This is in sharp contrast to the previous site selection effort in the county that failed after the county spent more than $600,000 to characterize a site underlain by the major aquifers that serve Champaign-Urbana.

**Lake County: Geologic Mapping for Solid Waste Facilities Siting,** *Abert, McLean, Riggs, Krumm, Smith, McKay, Denhart, Junkins, Helm* A part of Lake County was selected for geologic mapping as a follow-up to suitability mapping previously completed by ENR/ORP. An extensive database of more than 8,000 wells was compiled for the 210-square-mile Lake County study area in the central and western parts of the county. Information in the well database was used to produce a preliminary set of 24 maps, including drift thickness, bedrock topography, and slice maps showing the extent and thickness of coarse materials (sand and gravel). An important contribution to this mapping effort included digital information that was provided by Lake County. Results of the mapping have been discussed during a series of meetings with Lake County staff who are presently determining siting criteria for a new sanitary landfill and a composting facility. When these criteria are determined, a map will be produced showing a combination of suitability and capability factors. Observations at selected outcrops in northeastern Illinois provided confirmation of stratigraphic relationships that have been interpreted from the cross-sections and maps developed for the project.

**Will County: Geologic Mapping for Solid Waste Facilities Siting,** *McLean, Riggs, Abert, Krumm, McKay, Denhart, Junkins* Initial data compilation efforts were begun for a part of Will County, and geologic mapping has been initiated to assist Will County with ongoing landfill site screening efforts. Information is being compiled for a study area of approximately 590 square miles, and the data include well log information (e.g., well type and location, thickness of geologic units) for about 5,100 wells and a digital file of the surface topography. This information is being supplemented with data collected for an aquifer assessment study by the ISGS Groundwater Resources Section. Project staff are compiling information on verified well locations, well elevations, thicknesses of three subsurface sand bodies, and the topography of the bedrock surface. The maps produced will be used by Will County for landfill siting.

**Evaluation of Yard-Waste Composting with Regard to Leaching of Toxic Residues,** *Kovacic (UIUC, Landscape Architecture), Bicki (UIUC, Agronomy); Cahill (ISGS)* A research proposal to establish a field-scale experiment to measure the fate of toxicants in runoff, leachate, and finished yard-waste compost was funded by the Office of Solid Waste Management and Research (OSWR) at the University of Illinois. The results will provide guidance for state and federal authorities in sighting and managing yard-waste composting facilities. Lewis Publishers has agreed to publish our initial report (submitted to OSWR). The main conclusion of that report was that the environmental fate of chemical compounds generated from yard waste is unknown.

### Hazardous Wastes

**Sorption by Clays of Cadmium and Lead from Municipal Incinerator Ash-Water Suspensions,** *Roy, Krapac, Steele* The incineration of solid wastes yields an ash that is usually landfilled, and there is a concern that the ash may contain high concentrations of potential inorganic contaminants that may leach into groundwater. The effect of chloride complexation in municipal incinerator ash leachate on the sorption of cadmium and lead by kaolinite and illite was evaluated by using batch-sorption methods. Chloride complexation can potentially reduce sorption, and therefore reduce the mobility of these metals, but cationic competition may also simultaneously suppress sorption and reduce the efficacy of a clay liner to act as a chemical barrier to groundwater contamination. At pH 12, the pH of acidic-gas scrubber ashes, cadmium was essentially insoluble while lead occurred in anionic forms. Anionic lead was readily sorbed by the two clays, and was not influenced by chloride or carbonate complexation.

Laboratory extracts of scrubber-fly ash were subjected to sorption measurements to generate some primary data on the ability of clay minerals to attenuate metals from this type of matrix. At pH 12, the "natural pH" of the ash, anionic lead was readily sorbed by kaolinite and illite. Sorption constants, derived from isotherms, suggested that lead would be relatively "immobile." When the ash sample was acidified to pH 6.85, the dissolution of chloride and calcium essentially eliminated cadmium sorption because of complexation and cationic competition. Cadmium was either "mobile" or "very mobile" under these conditions. Lead was not soluble. The persistence of incinerator ash to buffer ash monofills, maintaining an alkaline pH, may minimize groundwater contamination from ash fills. The recent concern that the acidic-gas scrubber ash from municipal solid waste will release lead because of its caustic nature should be reevaluated in light of this study. This project was funded by the USEPA.

**Underground Injection Control Class I Service Program,** *E. Smith* The ISGS continued to provide technical expertise and advice to the Illinois EPA and USEPA, Region V, in the Class I Underground Injection Control Program. Activities include review of permit applications, permit modifications, monthly operating reports, and other related technical documents pertaining to the hazardous waste injection wells and review of the local and regional geology and hydrogeology of these sites. A computerized database of information submitted by well operators, designed to facilitate the review process, continues to be updated. A manual for the database was revised to facilitate training and operation of the database. IEPA staff have received training in the use of the database.

Responses to comments from three petitions for the continued injection of hazardous wastes were reviewed. Also evaluated in FY 1991 were the results of one mechanical integrity test and a groundwater monitoring plan requiring the installation of a monitoring well. In addition, two requests for minor permit modifications and two final permits were reviewed.

### Low-Level Radioactive Wastes

**Continued Technical Assistance to Battelle Relative to the Low-Level Radioactive-Waste (LLRW) Site Characterization,** *Berg, Curry, M. Cartwright, K. Cartwright, Weibel, Pool, Mclean, Taylor, McKay, Hackley, Liu* The state is actively working to locate a LLRW disposal site.

The ISGS reviewed final site characterization documents from siting contractors at the candidate sites at Martinsville in Clark County and Geff in Wayne County. Chapters on stratigraphy, hydrology, geochemistry, seismicity, mineral and hydrocarbon resources, and groundwater modeling have been formally reviewed under Battelle quality assurance procedures by ISGS staff. These chapters became volumes 2 and 3 of the site characterization documents. Two ISGS geological reports for Battelle on the glacial geology of the Martinsville site were completed and submitted to Battelle. This followed collection and analysis of about 1,500 samples for determination of clay mineralogy. In addition, two journal articles were submitted and accepted concerning our site characterization activities at Martinsville and Geff, respectively.

In conjunction with its efforts to characterize the Martinsville low-level radioactive-waste site, the Battelle Memorial Institute contracted with the ISGS to construct computer-generated three-dimensional models of the Quaternary geology of the Martinsville Alternative Site. One model helps non-geologists visualize the complex glacial deposits in the Martinsville area. Another displays the variation in the composition of the "upper sand", the primary aquifer for the Martinsville community, and a third displays the variation in hydraulic head in the major hydrologic units at the site.

The ISGS Isotope Geochemistry Laboratory has been the primary laboratory for radiocarbon ($^{14}C$) dating of groundwater at the two potential low-level radioactive waste repository sites (Martinsville and Geff) for the state of Illinois since 1988. Since July 1990, an additional 18 $^{14}C$ dates(17 groundwater samples, 1 methane sample) from southwest of the Martinsville site have been reported to the funding agency. The preliminary isotopic results of the project were presented at the GSA 1990 Annual Meeting in Dallas, and an abstract, "The Effect of Microbial Methane Formation on $\delta^{13}C$ Value and Radiocarbon Age of the Dissolved Inorganic Carbon (DIC) in Groundwater," was published in the GSA Abstracts and Programs, 1990. In the same period, one paper, "Radiocarbon Dating of Groundwater Containing Microbial Methane," was presented at the 14th International Radiocarbon Conference in May at Tucson, Arizona, by Keith Hackley, and it is currently under peer review by *Radiocarbon* for publication. The manuscript of a second paper, "Influence of Microbial Methane Formation on $\delta^{13}C$ and Radiocarbon Age of Dissolved Inorganic Carbon (DIC) in Groundwater," has just been completed.

**Site Characterizations of Bedrock Stratigraphy at the Geff Alternative Site,** *Weibel and Berg* A review of the procedure of site characterization of bedrock stratigraphy at the Geff Alternative Site for low-level radioactive waste disposal, Wayne County, Illinois, was presented at the 1991 annual meeting of the Geological Society of America. Modifications for future site characterization studies were recommended. The paper will be published in the journal *Environmental Geology and Water Resources.*

### Coal Wastes

**Use of FBC Wastes In the Reclamation of Coal Slurry Solids,** *Dreher, Roy, Steele* This research proposal was submitted for funding to the Center for Research on Sulfur in Coal, Carterville. In the proposed research, fluidized-bed combustion (FBC) wastes, which are expected to contain high concentrations of alkaline materials, will be mixed with coal slurry solids. The coal slurry solids are fine-grained materials that readily produce acid when contacted by air and moisture. The object of the research is to determine the ability of the FBC wastes to neutralize the acid produced by the coal slurry solids and prevent the leachability of toxic trace elements into aqueous solution. If the research is successful, it could lead to a method of reclaiming coal slurry ponds without the necessity of providing a thick topsoil cover prior to revegetation.

**Recovery of Coal Fines from Preparation Plant Effluents,** *Khan and Baxter* ISGS is a subcontractor to Praxis Engineers, of Milpitas, California, in preparing and characterizing samples for testing in a column flotation effluent processing project. Effluent samples were collected from four operating mines in Illinois. Particle size distribution was determined on splits from these samples, and sink-float tests were run. The bulk samples were partially dewatered by decantation and shipped to Michigan Technological University, Houghton, Michigan, where tests utilizing a column flotation process being developed at the Michigan university were carried out.

**Flotation Behavior of Coal from the Effluent Wastes Using Seven Different Reagents,** *Khan and Baxter* During the current reporting period, the flotation behavior of coal from the effluent waste stream of a single Illinois processing plant was examined using seven different reagents and a standard flotation method. For a given condition, the amount of coal floated was five to six times greater, and the ash content was about half with these reagents compared to the amount of coal and ash recovered from the same material with a reference reagent 2-ethyl-hexanol. Five of the reagents outperformed MIBC (a standard in the industry) in the recovery of combustibles.

### Technology Transfer and Information Services

**Workshop For County Governments,** *Krumm, McKay, McLean, Abert, Riggs, Pool, Bhagwat* On May 8, 1991, the Geological Mapping and Digital Cartography Section hosted a workshop for county officials to present information on the County Assistance Project. Representatives from 12 counties and two multi-county planning agencies attended the workshop. The two planning agencies represent 12 counties in southern and southwestern Illinois. Several presentations by staff from the ISGS, the ENR Office of Recycling and Renewable Resources, and the Office of Research and Planning discussed the

GIS mapping assistance that is available to counties to aid them in waste disposal facility siting. Ms. Laura Marshall from the Champaign County Intergovernmental Solid Waste Disposal Association presented a talk from a county-level perspective. The program also featured an on-line GIS mapping demonstration. Several counties including Adams, Carroll, Jackson, and LaSalle expressed interest in participating in the landfill siting assistance program.

**Disposal of Low-Level Radioactive Waste,** *K. Cartwright and Berg* The LLRW Siting Commission hearings regarding the siting of a low-level radioactive waste facility near Martinsville began May 29, 1991 and will continue through the fall. Cartwright and Berg will be required to testify.

**Deep Well Disposal of Industrial Waste,** *K. Cartwright* Testimony was provided to the Illinois Pollution Control Board (PCB) in May and June 1990 on the deep well injection of industrial wastes (UIC program). The HWRIC funded report, *Evaluation of Underground Injection of Industrial Waste in Illinois* (Illinois Scientific Surveys Joint Report 2), served as the ENR's written testimony to the PCB. During this period, Cartwright worked with the department to respond to comments on his testimony, and to comment on testimony by other groups that was critical or used in ISGS data and conclusions.

## EARTH HAZARDS AND GEOTECHNICAL STUDIES

Many natural and manmade hazards present potential risks to humans, and human activities produce damage to structures throughout the state. Studying, documenting, and understanding the mechanism of each hazard or set of hazardous conditions contribute to risk assessment and plans for coping with these problems. Some hazards such as landslides and coal mine subsidence impact small areas, whereas earthquakes and foundation problems associated with soils and moisture can be widespread. In addition, studies conducted on material properties of soil and rock aid in understanding the mechanisms, help predict impacts, and contribute to a database used for siting residential, industrial, and public construction projects.

### Radon

**Radon and Naturally Occurring Radioactivity,** *Cahill* Indoor radon continues to be an issue in Illinois. We receive requests for site-specific information on levels of indoor radon from both the public and private sectors. One research question about the occurrence of radon is whether its distribution can be mapped with high enough resolution to predict its occurrence at a specific location. Funding to investigate this question has thus far been unavailableg. Funding was sought from the U.S. Army CERL to study the geochemical associations and properties of radon that could lead to a predictive tool.

The ISGS radon database, which contains about 16,000 measurements arranged by zip code, was obtained from the Illinois Department of Nuclear Safety (IDNS) and several private companies.

### Landslides

**Landslides in the New Madrid Seismic Zone,** *Su and Stohr* A study to identify earthquake-induced landslides is on-going along a segment of the bluffs of the Ohio and Mississippi Rivers from Olmsted to Chester in southern Illinois. The study is investigating the hazards of earthquake-induced landslides by using various techniques of landslide inventory, history/age determination, and slope stability analysis. The major tasks included in the study are (1) compilation of a landslide inventory using aerial photography, 35-mm color and color infrared slides (photography from low altitude airplane flights), and side-looking airborne radar (SLAR) imageries with field checks; (2) development of a soil-stratigraphy technique for determining history and age of landslides; (3) determination of failure mechanisms and slope stabilities of landslides; (4) identification of factors contributing to landslide failures through geostatistical analysis; (5) assessment of regional landslide risks and detailed investigations of some sites; and (6) development and implementation of a prototype PC-based database and geographic information system (GIS) for the study area. This study is funded by the USGS through the National Earthquake Hazards Reduction Program (NEHRP).

### Earthquakes

**Paleo-liquefaction Features in Illinois,** *Su* In cooperation with Steve Obermeier of USGS, ISGS personnel are searching areas in Illinois along river banks of the Wabash and its tributaries for possible "paleo-liquefaction" features. A number of features that may be related to seismic events have been found along several tributaries in 6 counties, and along the Wabash from the Ohio River up to Terre Haute. Wood fragments from two sites were carbon dated at 2,250 and 7,500 B.P. Additional field and

laboratory work are being performed to ascertain the nature of these features and the possible relationship of all the features to the fluvial and seismic history of these valley deposits.

**Enhancement of Body-Wave Amplitudes by Loose, Surficial Deposits**, *Heigold* Any realistic assessment of the seismic risk of a region should take into account the contribution of surficial deposits to anomalously high seismic intensities. A paper, currently in preparation, shows that loose, surficial deposits, which are often prone to liquefaction, are also capable of enhancing the amplitudes of transmitted body waves.

The analyses presented in this paper can serve as a basis for more practical studies. If the elastic parameters of the surficial deposits and the subjacent bedrock can be measured, subregions where amplification of body waves will take place can be identified.

**Mine Subsidence**

The Illinois Mine Subsidence Research Program was established in 1985 to develop guidelines for underground mining methods that would maximize coal extraction while preserving the productivity of prime farmland in Illinois. The program also addresses the mining industry's need for calculation of stable mine conditions in room-and-pillar mines and subsidence predictions. The program was initiated at the request of the Illinois Coal Association and the Illinois Farm Bureau and is directed by the Illinois State Geological Survey. Work is being coordinated among the U.S. Bureau of Mines, University of Illinois at Urbana-Champaign (Department of Agronomy), Southern Illinois University at Carbondale (Department of Mining Engineering), Illinois Department of Mines and Minerals, and Northern Illinois University (Department of Geology). Funding is provided by the Illinois Coal Development Board and the U.S. Bureau of Mines.

**Illinois Mine Subsidence Research Program (IMSRP)** Activities from July 1989 through June 1990 were documented in a Program Assessment Report which was approved by the Illinois Coal Development Board (ICDB) at their March 1991 meeting. The ICDB also approved the 1991-1992 Program Implementation Plan (PIP). In April, Robert Bauer was named IMSRP Director, to succeed Paul DuMontelle.

Researchers are monitoring the effects of subsidence on surface response, overburden deformation and piezometric changes over previously mined, longwall panels in Jefferson and Saline counties. At these locations, surface subsidence characteristics are similar to earlier Illinois studies, but overburden deformation and piezometric response are more site-specific. Data are being analyzed from a grid of monuments that had a longwall-subsidence wave pass through it at the Saline County site. The grid will help determine three-dimensional displacements and strains through an area about the size of a house foundation. A draft final report is being prepared on monitoring results from the first overburden site in Williamson County.

Colin Booth, Northern Illinois University (NIU) Geology Department, is investigating the hydrogeologic effects of subsidence. Work continues on development of a model to simulate the effects of longwall mining on ground water in the Illinois Coal Basin. Data from the Illinois Department of Mines and Minerals are being integrated with geologic and hydrogeologic information to form the model. A poster session on the hydrologic studies was presented at the Fourth International Symposium on Land Subsidence, Houston, TX, in May. In conjunction with Dr. Booth, Phillip Carpenter, also of NIU, studied the application of surface geophysical methods to the investigation of mine subsidence. Two presentations concerning preliminary results of the Saline County geophysical work were given at the annual meeting of the North Central Section of the Geological Society of America in Toledo, OH, in April.

At a Franklin County longwall operation, IMSRP researchers logged core obtained from a drill hole installed by the U.S. Bureau of Mines, and assisted in placing a time-domain reflectometry (TDR) cable in the drill hole to monitor subsidence movements. The cable was subsided during June 1991, and ISGS researchers and others monitored the cable using a remote data acquisition system. The core is being tested in the ISGS Rock Mechanics Laboratory; the testing results will be correlated with data from the TDR cable.

Robert Darmody of the University of Illinois Agronomy Department continues to investigate the effects of subsidence on agricultural soils and the impact of current subsidence mitigation practices on crop yields. Yields at the mitigated sites were depressed in 1990 because of the wet spring weather; these

results are highly weather-dependent and will require one more year of data collection. A report summarizing the first three years' work is in preparation.

Paul Chugh of Southern Illinois University directed an ongoing project on surface subsidence monitoring. Researchers are trying to predict subsidence for partial extraction panels and a pillar extraction panel, using two different models. A personal computer version of the partial extraction model was completed, sample programs were tested, and a user's manual is in preparation. Dr. Chugh and Heinz Damberger of the ISGS Coal Section are completing a project to identify characteristics of Illinois mines in regard to their geology and mine stability problems. Mine permit data from the Illinois Department of Mines and Minerals and roof fall data from the Mine Safety and Health Administration are being incorporated with information from site visits and questionnaires.

**Minerals Associated with Mine Subsidence,** *Hughes, Moore, DeMaris* Roof and floor strata in Illinois coal mines often yield during or after mining, and may cause hazards within the mine and at the surface of the earth. Clay mineral content and abundant, expandable, clay minerals are suspected causes of these failures. Two studies have been undertaken to determine the degree to which measures of mineralogical content correlate with engineering test data and the actual failures. An explanation of the fundamental causes of failure may help prevent future problems and suggest remedial procedures for existing problems. The analyses have been completed for a study of roof and floor strata. This study is supported in part by IMSRProgram and the Peabody Coal Company. The mineral contents were only weakly correlated to measures of core swelling in water. The main reasons for the weak correlation were (1) only a few of the samples were underclays; (2) no measure of cementation by organic matter and carbonate minerals was included; (3) the swelling data had to be converted from time and magnitude to a single number for the correlation—probably a questionable conversion.

### Rock Mechanics and Geotechnical Support Studies

**Engineering Geology Database (EGDB) and Geographical Information System (GIS),** *Su* This project is supported partly by the University Grant Program (valued at $34,750) from Generation 5 Technology (Denver, Colorado) and Autodesk (Sausalito, California). The project integrates Geo/SQL, Autocad, and Oracle into a development tool for PC-based database and GIS applications. The EGDB and GIS are designed to be comprehensive and accessible to a wide range of users. End-users, through modem communication, local-area network or wide-area network, will be able to use simple menu-driven commands to execute interactive query from various remote centralized data resources in their PCs. The user-requested information can be displayed on the monitor as both geographic map and tabular data.

The database is currently being developed using the SQL TABLE concept. Thousands of engineering boring records and test results that are available on paper will be transferred into electronic format using the same Oracle database structure of the existing ISGS well data tables (i.e., a header table, a lithologic table, and a stratigraphic table). Therefore, the same primary keys can be used to retrieve both engineering geology records and all basic geologic information. In the system, the Autocad software is used to display user's requested base map and well locations. Custom designed pop-up menus will assist users to construct SQL commands for retrieving or updating database information through the Geo/SQL software. All interactions are done graphically using the 'point-and-shoot' method. No programming experience is needed to use the system.

Geology and geotechnical information from the USGS landslide project and the Advanced Photon Source (APS) project are being used to test this computer application. Once a mature prototype is completed, we will attempt to publish a paper, journal article, or general media article regarding the work undertaken through the project.

### Technology Transfer and Information Services

**Proximity of Underground Mines to Residential and Other Built-up Areas in Illinois,** *C. Treworgy and Hindman* A publication on this topic was released as Environmental Geology 138. It resulted from a project supported by the Illinois Mine Subsidence Insurance Fund (IMSIF) to evaluate the potential for mine subsidence county by county based on the proximity of underground mines to urban areas.

**Mine Subsidence Information Dissemination,** *Trent, Bauer, Van Roosendaal, B. Mehnert, Kelleher* Press releases were distributed in early July to coal, engineering, and agricultural magazines. News covered in the releases included contracts granted by the Illinois Coal Development Board for subsidence research, and the Environmental Success Award won by the IMSRP.

Thirty environmental educators who gathered at the Western Illinois University Science Education Center in February received IMSRP publications and other materials on mine subsidence. This was part of the CLASS (Conservation Learning Activities in Science and Social Studies) project for the State of Illinois.

On March 1 and 2, the IMSRP displayed an exhibit at the University of Illinois College of Agriculture open house. The display focused on agronomic and groundwater investigations associated with active mine subsidence. Publications were available for open house visitors, and IMSRP staff were on hand to answer questions.

Plans were made for the IMSRP to act as a cooperating group with the August 1992 National Symposium on Prime Farmland Reclamation. Calls for papers were mailed in May. A subsidence session will be included in the 70 papers.

Requests for searches of the IMSRP bibliographic database were filled. Publishers' permission was received to reprint several papers by IMSRP authors. Many publications were mailed out in response to inquiries.

**Computer-Assisted Directory of Mine Subsidence Insurance Claims,** *Coates, Bauer, Kelleher* The Illinois Mine Subsidence Insurance Fund (IMSIF) supports the PC-INFO database of mine subsidence insurance claims from the entire state. Funding for the directory has continued since 1983, and there are now more that 4,100 records of claims in the database. Included are data on structure type, causes of damage, location of insured structures, and information on underlying mines. The database is searched to answer questions concerning subsidence events in an area or over a specific mine.

# General and Basic Research

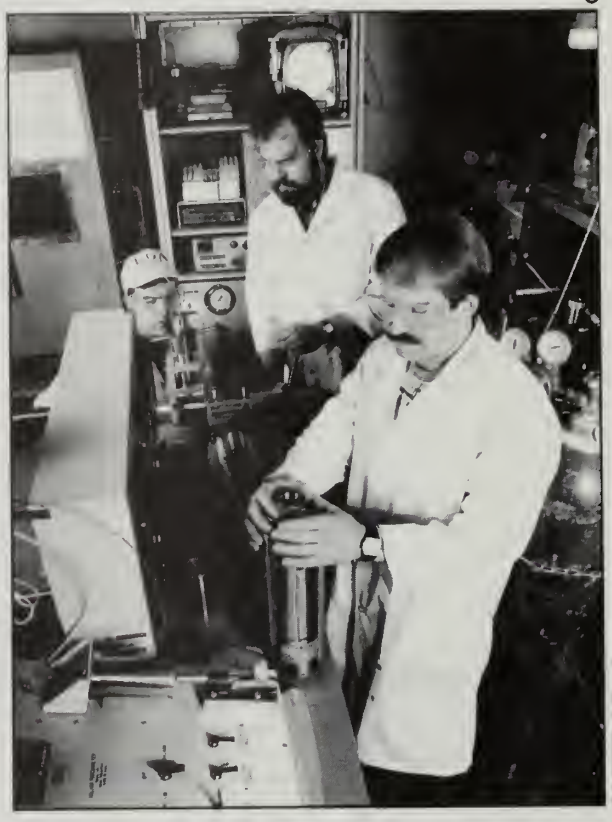
A



B

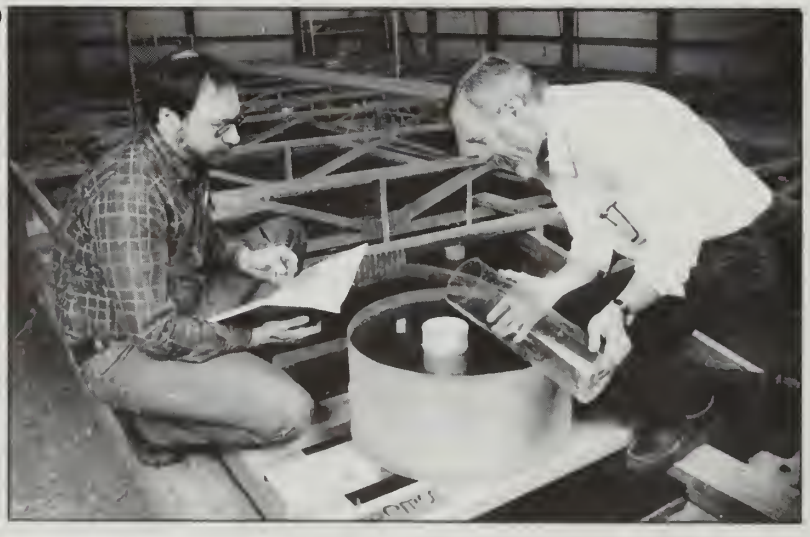


C



(A) Don McKay (from left), Lisa Smith, and Bob Pool of the Geologic Mapping and Digital Cartography Section examine a sand isolith map of Lake County prepared using GIS software. The map will be used to help site a landfill in Lake County. (B) Geologist Joe Devera examines a fossilized log in a bedrock outcrop in southern Illinois. (C) In the Oil and Gas Section, Joe Fagan (from left) and Scott Beaty do a capillary pressure analysis on a sandstone core sample while Dennis Haggerty prepares a sample for a core holder. (D) Keros Cartwright (right) of Special Studies and Hydrogeology Research Laboratory, and Ivan Krapac, geochemist, measure evaporation rates as part of a study on the infiltration of water into soil liners.

D



## GENERAL AND BASIC RESEARCH

General and basic research includes fundamental research programs of the Mineral Resources and Engineering Branch and the Environmental Geology and Geochemistry Branch at the Illinois State Geological Survey (ISGS). Geologic mapping provides the basic data required to address many environmental and resource problems; for example, without geologic maps at an appropriately large scale, the extent of environmental damage or the precise location of mineral resources can not be estimated. Using geologic maps, drill hole data, lithologic logs, and geophysical reflection and refraction records, geologists construct cross sections of the earth's subsurface to extrapolate geologic knowledge laterally and at depth. As this framework is developed at larger scales, the Illinois Basin as a whole comes into focus. Hydrologic, geochemical, and mineralogic data can be incorporated to analyze the fluid and solid, physical and chemical history and composition of the basin and solve today's earth-related problems. Paleontological and isotopic studies permit dating of geologic events, including the processes that formed Illinois' mineral resources and modified the geological environment.

ISGS databases of essential geologic, geochemical, and geophysical information continue to grow as mandated or other required information is acquired or solicited. Computer research permits visual and mathematical manipulation of the data, making information accessible to the private and public sectors.

### GEOLOGIC AND TOPOGRAPHIC MAPPING AND REMOTE SENSING

Geologic maps and cross sections delineate the areal and vertical distribution of geologic units of the landscape. Geologic information at appropriately large scales is required for environmental protection and resource identification. The ISGS is seeking opportunities to expand its geologic mapping program. The National Geologic Mapping Program (NGMP), now before Congress as the National Geologic Mapping Act of 1991 (H.R. 2763 and S. 1179), is a part of this effort; it will provide matching monies for mapping by the State Geological Surveys. The ISGS prepared a report on the status, need, and plans for a statewide geologic mapping program in response to Illinois Senate Resolutions 881 and 98.

Topographic maps, planimetric maps, and digital cartographic data are the basic products of a program conducted in cooperation with the U.S. Geological Survey (USGS). These data may be compiled with geologic and other thematic data, by using a Geographic Information System (GIS). The current priority of ISGS is to complete the 1:100,000-scale county map series. Priorities have also been established, with the support of other state agencies and the USGS, for 1:24,000-scale digital map products.

Remote Sensing techniques include aerial photography and other imagery used for data collection and analysis to aid in geologic, hydrologic, and mineral resource mapping.

#### Geologic Mapping

**Illinois Geologic Mapping Advisory Committee (IGMAC)** IGMAC was organized in 1988 to provide counsel and support in the planning of a major geologic mapping program to meet the state's needs. IGMAC met in November 1990 and May 1991; the membership includes representatives of state and federal government, industry, and academia. Semiannual meetings provide an excellent forum for exchange of perspectives on the need for and potential direction of a state mapping program. Chief Leighton serves as permanent Secretary of IGMAC.

The committee reviewed and approved a comprehensive, draft report, "Geologic Mapping for the Future of Illinois," which summarized the status and needs for statewide geologic mapping. This report was prepared by ISGS staff, under the direction of Dr. Damberger, Chairman of the ISGS Mapping Committee, in response to a Illinois Senate resolution that ordered the submission of such a report to a Senate Geologic Map Task Force (see below). During preparation of the report, a Working Committee on Geologic Mapping with representatives from key state agencies and industries, assisted and advised the ISGS on the needs of government and industry. They also approved the report before submission to the Senate in June 1991.

**Geologic Mapping for the Future of Illinois,** *Leighton, Eidel, Damberger, McKay, Bhagwat, Mapping Committee* The ISGS prepared the report, "Geologic Mapping for the Future of Illinois," for the Illinois Senate Committee on Geologic Mapping. It includes a detailed analysis of geologic mapping needs and prioritizes the 1,073 7.5-minute quadrangles in the state. The report concludes that less than 3 percent of the state has been mapped at a scale adequate for modern needs, that is, at a scale of 1:24,000 (1 inch = 2,000 feet). A benefit/cost study, completed to accompany the report, used a mapping program

in the Boone/Winnebago County area to demonstrate most likely benefit-to-cost ratios of 12 to 1 to 27 to 1 for that effort. When expanded for the entire state the analysis of most likely benefit-to-cost ratios ranged between 3 and 7. The overall cost of mapping the geology of Illinois at a scale of 1:24,000 (1 in. = 2,000 ft) was estimated at $55 million. Assuming a 50/50 match of state and federal funds, totaling $2.2 million per year, the program would require 25 years to map the entire state. This could be reduced to 17 or 18 years with contributions from the counties.

**Benefits and Costs of Geologic Mapping Programs in Illinois: The Case of Boone and Winnebago Counties and its Statewide Applicability,** *Bhagwat and Berg* The Illinois Senate Resolution 881 required that the benefits and costs of geologic mapping programs be assessed by the ISGS. As detailed mapping was conducted by the ISGS in 1980 in Boone and Winnebago Counties, these counties were selected for the case study. Project-specific studies assessing the benefits and costs of using geologic information have been conducted in elsewhere in the country; however, this is the first benefit/cost study of large-scale geologic mapping programs in Illinois and in the United States.

The benefits of geologic mapping are many. Direct benefits accrue, for example, from selection and designing of waste disposal and industrial sites, urban development and zoning decisions, planning of mineral exploration and extraction strategies, and infrastructure planning. Indirect benefits are obtained from avoided contamination of land and water, and improvements in public health and education. Many of the benefits are difficult to quantify in dollars. This study was based on a single quantifiable benefit derived from future avoided costs of cleaning up waste disposal and industrial sites, although many other quantifiable and nonquantifiable benefits were monitored and listed.

The cost of mapping also involves direct costs such as those for the mapping activity itself; indirect or social costs arising from higher transportation costs due to distances from geologically ideal sites and potential displacement of businesses to other geographic areas; and opportunity costs of alternative uses of the money spent on mapping. Included in the study were only the directly measurable costs of mapping. The benefits and costs were compared in terms of 1990 dollars.

Considerable uncertainty exists in assessing the benefits that are expected to accrue in decades to come because of the uncertain impact of existing and potential environmental regulations. Environmental regulations are in place for waste disposal sites; however, statewide regulations concerning industrial sites have yet to be passed. As a result, future benefits were assessed in three scenarios: in scenario 1, the benefits were discounted by 50 percent to account for the fact that industrial sites have yet to be regulated; in scenario 2, it was assumed that a partial effect of industrial sites regulations will be experienced in the next 3 decades, and therefore, benefits were discounted by 75 percent; and in scenario 3, the full impact of existing and future regulations was accommodated by discounting the benefits by 90 percent. Benefit/cost ratios for Boone and Winnebago Counties ranged from about 5 to 11 in the most conservative scenario 3, and from 23 to 54 in the least conservative scenario 1.

On the statewide level, uncertainties on the cost side were taken into account by introducing a higher cost scenario to accommodate geologic and other differences from county to county. Statewide projections of benefits and costs were based on county-to-county differences in the groundwater contamination potential as well as the county size. The statewide benefit/cost ratios in the most conservative scenario 3 were 1.2 to 2.8 under the lower cost assumption and 0.5 to 1.1 under the higher cost assumption. In the least conservative scenario 1, the corresponding ranges of benefit/cost ratios were 6 to 14 and 2.3 to 5.4.

The benefits of geologic mapping in Illinois thus clearly justify the mapping programs on the basis of the benefit/cost ratios, even though only one category of benefits was quantifiable. The study is available as ISGS Open Files Series 1991-5 and will be published as an ISGS Circular.

The results of the study on benefits and costs of geologic mapping programs were presented by Subhash Bhagwat at the following meetings:

- Illinois Geologic Mapping Advisory Committee (IGMAC) at Starved Rock, November 15, 1990;
- Board of Natural Resources at Eagle Ridge, Illinois, May 3, 1991;
- McHenry County College, Crystal Lake, Illinois, May 7, 1991, at the workshop, "A Primer on the Essentials for Groundwater Protection," organized by the McHenry County Board of Health and McHenry County College;
- workshop for county governments, "GIS Mapping Projects to Support Solid Waste Facility

Siting,"hosted by the Illinois Department of Energy and Natural Resources (ENR), Office of Solid Waste and Renewable Resources (OSWRR), Illinois State Geological Survey (ISGS), and Office of Research and Planning (RAP) and held in Champaign, Illinois.

In addition, the results were presented by Chief Leighton to the USGS/AASG-sponsored Eastern Cluster Meeting in Reston, Virginia, on February 23, 1991, and to the Association of American State Geologists (AASG) at its annual meeting May 4-8, 1991.

**COGEOMAP: Geologic Quadrangle Mapping,** *Damberger, Nelson, Weibel, Devera, Jacobson* Geologic mapping of the first fifteen 7.5-minute quadrangles in southern Illinois is nearing completion. Three maps have been released. The remaining geologic quadrangle maps, at a scale of 1:24,000, are in various stages of preparation. The Waltersburg Quadrangle is in production at Northern Illinois University's Cartographic Laboratory. The Bloomfield Quadrangle map and report are in review. Field work for the Lick Creek and Cobden Quadrangles is complete and maps are in preparation. This program is conducted in cooperation with USGS.

- **Geologic Map of the Creal Springs Quadrangle,** *Trask and Jacobson* Bids to print the full-color map from the four negatives produced by the Cartographic Laboratory at Northern Illinois University (NIU) were obtained. The map was printed and released in August 1990.

- **Geologic Map of the Eddyville Quadrangle,** *Nelson and Lumm* Bids to print the full-color map from the four negatives produced by NIU's Cartographic Laboratory were obtained. The map was printed and released in August 1990.

- **Geologic Map of the Stonefort Quadrangle,** *Nelson and Lumm* Bids to print the full-color map from the four negatives produced by NIU's Cartographic Laboratory were obtained. The map was printed and released in August 1990.

- **Geologic Map of the Goreville Quadrangle,** *Jacobson* Various proofs resulting from NIU's scribing and production of the negatives for color separation were reviewed. The negatives are ready for the printer.

- **Geologic Map of the Waitersburg Quadrangle,** *Weibel, Nelson, Devera* The final draft of this map was completed and submitted to NIU's Cartographic Laboratory for scribing and production of negatives for color separation. Proofs were reviewed and NIU is ready to prepare the final negatives needed by the printer.

- **Geologic Map of the Glendale Quadrangle,** *Devera* The final draft was prepared, reviewed, revised, and sent to the NIU Cartographic Laboratory to be scribed and prepared for printing.

- **Geologic Map of the Lick Creek Quadrangle,** *Weibel and Nelson* The compilation of the geologic map on a greenline base was nearly completed.

- **Geologic Map of the Makanda Quadrangle,** *Weibel and Jacobson* The compilation of the geologic map on a greenline base is underway.

- **Geologic Map of the Bloomfield Quadrangle,** *Nelson* Work on this map was on temporary hold due to Mr. Nelson's 1-year stay at the Montana Geological Survey, on a staff exchange program.

- **Geologic Map of the Cobden Quadrangle,** *Nelson and Devera* Compilation of the draft geologic map on a greenline base has been completed.

- **Geologic Map of the Gorham Quadrangle,** *Devera and Weibel* Field work on this quadrangle was completed and the compilation of the geologic map on a greenline base is underway.

- **Geologic Map of the Wolf Lake Quadrangle,** *Devera* The draft of the geologic map of this quadrangle had to be revised due to structural complexities found in the Gorham Quadrangle immediately to the north.

- **Geologic Map of the Altenburg Quadrangle,** *Devera* Field work was nearly completed.

- **Geologic Report on the Creal Springs, Eddyville, and Stonefort Quadrangles,** *Nelson, Jacobson, Trask, Devera, Riggs, Follmer (ISGS); Esling, Lamon, Henderson (Southern Illinois University [SIU[)* This report was published as ISGS Bulletin 96.

- **Geologic Report on the Goreville Quadrangle,** *Jacobson* Administrative review of this report was completed and some changes made following the completion of the review process. The report is currently in production for publication as ISGS Bulletin 97.

- **Geologic Report on the Waltersburg Quadrangle**, *Weibel and Nelson* Peer review was completed, and needed modifications were made. The report is in administrative review.

- **Geologic Report on the Glendale Quadrangle,** *Devera* The technical review was completed and corrections are underway.

- **Geologic Report on the Lick Creek Quadrangle,** *Weibel and Nelson* Writing of this report has been initiated.

- **Geologic Report on the Makanda Quadrangle,** *Weibel and Jacobson* This report has been partially drafted, but work on it was on hold during the report period.

- **Geologic Report on the Bloomfield Quadrangle,** *Nelson* The map was peer reviewed.

- **Geologic Report on the Cobden Quadrangle,** *Nelson and Devera* The report is in the process of being written.

- **Geologic Report on the Gorham Quadrangle,** *Devera and Weibel* A draft of this report is in the initial stages of writing.

- **Geologic Report on the Wolf Lake Quadrangle,** *Devera* The manuscript is currently being drafted and photographic plates are being made.

- **Geologic Report on the Altenburg Quadrangle,** *Devera* This manuscript will not be started until all fieldwork has been completed.

- **Diamond Drill Program 1991,** *Damberger, Devera, Nelson, DeMaris, Reed* Two stratigraphic test wells were completed, one on the Cobden, the other on the Gorham quadrangle. Valuable information on the structure and stratigraphy of Mississippian and Pennsylvanian rocks in this region was obtained.

- **Mapping the Jonesboro, Mill Creek, Tamms, and Thebes Quadrangles,** *Nelson, Devera, Masters, Norby* A new contract for geologic mapping in southern Illinois has been signed by the ISGS and the USGS. The contract, which commenced June 1, 1991, calls for the ISGS to produce geologic maps of the Jonesboro, Mill Creek, Tamms, and Thebes Quadrangles within 2 years.

- **Cooperative Geologic Mapping Program (COGEOMAP),** *Kempton, Berg (ISGS); D. Soller (USGS)* In an expansion of the COGEOMAP program this year, the USGS awarded the ISGS a contract to develop an advanced methodology for three-dimensional mapping of Quaternary deposits. The 1991 Cooperative Geologic Mapping Program (COGEOMAP) of the USGS recommended support of the proposal, "Three-Dimensional Geologic Mapping of Quaternary Deposits in the Champaign 1:100,000-Scale Quadrangle, Illinois." A proposal was submitted as requested in mid-May. John P. Kempton, Richard C. Berg, and David R. Soller (USGS) are directing the first of a 3-year project, which is funded this year at $50,000 and $15,000 in kind by the USGS.

**A Methodology for Displaying Three-Dimensional Lithostratigraphic Relationships in Color,** *Berg and Greenpool* This paper describes a mapping system that allows a viewer to recognize regional geologic trends and relationships of three-dimensional lithostratigraphy. The stack-unit method of mapping to 50 feet is used in conjunction with the ISGS Geographic Information System (GIS) to portray these sequences and relationships using color with line or dot patterns. Color categories denote marked lithologic differences (e.g., geologic periods or provinces), while shades of colors denote variations within the major groups. Line or dot patterns in combination with these colors further represents sequence

features such as unit thickness, depth to the surface, or the nature of the material (e.g., lithified, semi-lithified, or drift materials). Because the color and pattern assignments are done in a systematic manner, visual comprehension of complex geologic trends and local geologic relationships are made available to the map user. This paper is currently under review and will be submitted to an appropriate journal.

### Topographic Mapping

**Acquisition of Digital Topographic Data,** *McKay and Krumm* Adding to its database of digital topographic information, the ISGS acquired 1:24,000-scale, digital line graph (DLG) data for Lake County and for the entire Paducah 1° × 2° Quadrangle covering southernmost Illinois, south of the latitude of Benton. In addition, digital topography was collected as part of the County Landfill Siting Assistance Study for much of Will County. DLG-format hydrography and transportation data from the USGS at 1:100,000 scale were added to the IGIS database in cooperation with the other scientific surveys and the Office of Research and Planning of the Illinois Department of Energy and Natural Resources (ENR).

**Cooperative Topographic Mapping,** *Stohr* New or revised editions of 125 7.5-minute quadrangle maps of northeastern Illinois (72), the Quad Cities area (32), and East St. Louis area (21) are being prepared; funding has been provided by the USGS. Orthophotography (aerial photography with radial distortion removed) is in progress for all of Jo Daviess and part of Champaign Counties.

Of the 46 maps in the 1:100,000-scale, 30×60-minute series, 41 have been completed as topographic editions. In the 1:100,000-scale county map series, 58 maps have been published and four have been completed as topographic editions, under joint funding agreement with Illinois.

Digital elevation data is available at the 1:250,000 scale for quadrangles; at the 1:100,000 scale for 12 quadrangles; and at the 1:24,000-scale for 200 quadrangles. Thirty-two others are in progress. Digital line graph data at the 1:100,000 scale are available for the public land survey system (PLSS), including boundaries, hydrography, transportation, and hypsography (elevations) for all of Illinois. Digital line graph data at the 1:24,000 scale are available for 104 quadrangles; five more quadrangles are in progress.

### Remote Sensing

**Remote Sensing Investigations for Siting and Monitoring Landfills,** *Stohr* In cooperation with the U.S. Environmental Protection Agency (USEPA) Remote Monitoring Systems Laboratory in Las Vegas, the ISGS collected color infrared aerial photography, and nighttime thermal infrared data over three landfills in east-central Illinois and one in northeastern Illinois. The data collection included coordination and contributions from several state and local agencies and private companies: Illinois Departments of Transportation and Corrections; University of Illinois Department of Education; cities of Urbana, Champaign, and Monticello and their consultants; Du Page County Forest Preserve; Danner and Associates; Lockheed Management Services, Inc.; and Berns and Clancy Associates. Two aircraft were used for the night thermal infrared data gathering. The flights will provide color infrared photography and thermal infrared imagery of closed landfills in Champaign and adjacent counties, and in Du Page County.

**Remote Sensing Investigations for Shallow Aquifers in Warren County, Illinois,** *P. Reed and Stohr* Field experiments were conducted to prepare for aircraft remote sensing for delineation of a shallow aquifer near Roseville in Warren County, Illinois. On December 16, 1990, field radiometric temperature measurements were made of two study areas. A short report was written.

**Remote Sensing Investigations for Shallow Aquifers in Will County, Illinois,** *Larson and Stohr* Nighttime thermal infrared imagery was collected over Hickory and Spring Creeks in Will County, Illinois, in June 1991. The data will be used to try to determine inflow of groundwater into the creeks and confirm the location of prominent joints and fractures.

## CRUSTAL STUDIES

Studies of the crustal framework in Illinois provide information about the processes that led to the origin and development of the Illinois Basin and surrounding domes and arches, controls on the distribution of natural resources, and deep crustal structures that influence earthquake activity.

Knowledge of the Midcontinent crustal framework has increased significantly in recent years as a result of regional geophysical studies. Such studies include deep seismic reflection profiling across the Illinois Basin by the oil and gas industry and by the Consortium for Continental Reflection Profiling (COCORP),

deep seismic reflection profiling in the southern Illinois Basin by the USGS, and gravity and magnetic maps of Illinois produced through a cooperative effort of the ISGS and USGS. Analyses of the data from these studies are far from complete. Acquisition of essential new data is planned.

Industry-sponsored reflection profiling has focused primarily on Phanerozoic rocks that contain the state's mineral resources. The ISGS is making an effort to acquire these and other proprietary geophysical data to increase its seismic library, a vital database for basin analysis. Focus of research during the report year was on (1) interpretation of proprietary seismic reflections near Hick's Dome in southern Illinois, (2) statewide compilation of aeromagnetic and gravity anomaly maps, (3) enhancement of body-wave amplitude by loose, surficial deposits, (4) analysis of gravity data over a 685 square mile area of south-central Illinois, and (5) analysis of a Proterozoic crustal boundary in the southern Illinois Basin.

### Potential Field Data

**Statewide Gravity and Magnetic Maps**, *Heigold* Aeromagnetic maps at scales of 1:1,000,000 and 1:500,000 and gravity maps at scales of 1:500,000 and 1:250,000 for the entire state have been compiled through a cooperative effort between the ISGS, USGS, and NIU. These maps, currently in review, will provide information about the structure and composition of the earth's crust and be useful in aiding mineral exploration.

**Deep Seismic Data,** *Heigold and Sargent* Two seismic reflection sections relevant to the CUSMAP Project have been acquired and interpreted by the ISGS. One section extends from the Mary Streich well in Pope County, Illinois, southeastward across Hicks Dome to near the Ohio River. The other extends from the Commodore Fault to the Claylick Fault in western Kentucky. The information contained in these sections not only increases the understanding of the structural framework of this area, but also provides additional insights into the evolution of the Illinois Basin.

## BASIN ANALYSIS

The Illinois Basin covers an area of approximately 60,000 square miles in the southern two-thirds of Illinois and adjacent parts of Indiana and Kentucky. The basin contains about 100,000 cubic miles of sedimentary rocks that yield valuable resources, including industrial minerals and metals, coal, oil and gas. These resources have greatly benefited the economic health of Illinois for many years. Basin analysis, a multidisciplinary method of research, contributes to the discovery and development of mineral resources in Illinois by providing information on the geologic framework of the Illinois Basin, thus improving prediction of mineral resource occurrences.

The ISGS Basin Analysis Program integrates geological and geophysical data to increase understanding of how the basin formed, filled with sediment, and changed after burial. The primary focus of research in the last year was on (1) construction of cross sections showing the structural and stratigraphic framework of the basin, (2) quantitative modeling to determine the mechanisms of tectonic subsidence in the Illinois Basin, (3) stratigraphic analyses of selected Cambro-Ordovician rocks to determine facies relationships, (4) completion of a compendium on the structural features in Illinois, (5) conodont biostratigraphy of selected lower Paleozoic rock units to facilitate rock correlation, (6) correlation of Ordovician volcanic ash beds, and (7) publication of a large report that examines interior cratonic basins and features the Illinois Basin. To capitalize on existing facilities and expertise, the ISGS has continued its cooperative research programs with the Indiana and Kentucky Geological Surveys and the USGS.

### Framework Studies

**Illinois Basin Cross Section Project**, *J. Treworgy, Whitaker, Sargent* The Illinois Basin Consortium (IBC), consisting of the Illinois, Indiana, and Kentucky Geological Surveys, is preparing a series of 20 regional structural cross sections in the Illinois Basin. These sections are providing valuable information on the structural history and stratigraphic framework of the basin. The sections are fundamentally important in the development of nearly all subsurface research projects in the basin.

The sections are constructed from wireline logs of the deepest wells available and portray the entire Phanerozoic section from top of Precambrian basement (as deep as 24,000 feet in places) up to the surface. Wireline logs have been digitized and "skeleton" cross sections have been generated on the GeoQuest workstation using Zycor's Stratview cross section software.

The first three cross sections were completed this year and are available as diazo reproductions through the ISGS Open File Series. Final publishing of the sections awaits completion of the entire set to ensure consistency in the correlations. A fourth cross section has been completed and will be drafted in the next reporting period. Three more cross sections, which are part of the CUSMAP, have been constructed and are in review.

The most expeditious way to complete the remaining sections is to contract a service company to digitize the remaining logs and to prepare the "skeleton" sections. The USGS has agreed to fund this portion of the project and is currently processing bids for the work. The IBC staff geologists will be responsible for geological interpretation and production of the cross sections.

**Silurian Lithostratigraphy and Biostratigraphy in Northeastern Illinois,** *Mikulic and Norby* Information from outcrops, quarries, and subsurface samples is being gathered in northeastern Illinois in order to establish a reference section of litho- and biostratigraphic features of the Silurian rocks of the area. This reference section will be the basis for local and regional correlation of these poorly known but economically important rocks. Study of conodonts from core samples is nearly completed and will be tied into outcrop and quarry sections. Extensive examination and sampling of outcrop and quarries has been conducted in Cook, Will, and Kankakee Counties.

### Structural Geology and Tectonic History

**Proterozoic Crustal Boundary in the Southern Part of the Illinois Basin,** *Heigold and Kolata* Recently acquired COCORP and proprietary seismic reflection data from the southern part of the Illinois Basin, combined with other geological and geophysical data, indicate that a west-northwest-trending Proterozoic crustal boundary lies beneath the 1.48-billion-years-old granite-rhyolite terrain within this area. The boundary lies along the projected trend of the northern margin of the Early Proterozoic Central Plains Orogen. The location of the boundary between the Wabash Valley Seismic Zone and the New Madrid Seismic Zone to the southwest may be a significant factor in the present-day seismicity of these two regions. A paper was presented on this topic at the meeting of the North-Central Section of the Geological Society of America in Toledo, Ohio, in April 1991. It is currently being revised and will be submitted to the journal, *Tectonophysics*.

**Mapping the Dixon Springs Graben,** *Nelson* Mapping is in progress for the bedrock surface and subsurface geology of the Dixon Springs Graben in parts of Johnson, Massac, and Pope Counties of southernmost Illinois. This mapping, combined with mapping already completed under COGEOMAP, will be the basis for a report on the tectonic history, economic aspects, and earthquake potential of this important fault zone. The Dixon Springs Graben apparently has a long history of movements and lies directly in line with the presently active New Madrid Seismic Zone. To date, no evidence has been uncovered that the graben is a likely location of a future earthquake.

**Mapping the DuQuoin Monocline,** *Nelson* Subsurface mapping was initiated along the DuQuoin Monocline in southern Illinois. The monocline is a major fold of earth strata, largely concealed by glacial deposits; it extends about 40 miles from DuQuoin to Centralia, Illinois. The purpose of the study is to determine the history of development of the monocline and how its development affected sedimentation that, in turn, controlled hydrocarbon accumulation in this oil-rich part of the Illinois Basin.

### Stratigraphy

**Tectonomagmatic and Stratigraphic Significance of Ordovician Volcanic Ash Beds in Eastern North America and Northwestern Europe**, *Kolata (ISGS); S. M. Bergstrom (Ohio State University): W. D. Huff (University of Cincinnati)* The goal of this project is to determine whether Ordovician age (450 million year old) ash beds present in eastern North America, including the Illinois Basin, can be correlated with the same age ash beds in northwestern Europe. A grant provided by the National Science Foundation allowed the research team to travel to Estonia, Sweden, and Norway during August 1990 to collect ash samples for comparison with those in North America.

Preliminary chemical data suggest that the two thickest and most widespread ash beds in eastern North America also occur in Europe. Because the ash beds were deposited rapidly (a flash in geologic time), they provide precise time lines for international correlations. They are key marker beds that can aid in the exploration of oil and gas and other mineral resources by providing precise geologic correlation that enables global extrapolation of resource-forming events.

Results of the study were published in the November 1990 issue of the American Association of Petroleum Geologists *Bulletin*, and a paper was presented at the meeting of the North-Central Section of the Geological Society of America in Toledo, Ohio, in April.

**Conodont Biostratigraphy of the New Albany Shale in the Southeastern Portion of the Illinois Basin,** *Norby (ISGS); Ettensohn (University of Kentucky)* An updated conodont biostratigraphy has been formulated for the Upper Devonian/Lower Mississippian rocks of Indiana and Kentucky. This new biostratigraphy will provide greater accuracy in correlating Upper Devonian rock units throughout the Illinois Basin. During this period, additional samples have been processed and picked to evaluate the the taxonomy. This is needed to provide additional support to the biostratigraphic framework previously presented. The paper will be submitted to the *Journal of Paleontology*.

**Middle Devonian Black Shales in Kentucky**, *Norby (ISGS); Ettensohn and Barnett (University of Kentucky)* The lithology and biostratigraphy of Middle Devonian shales were compared with the shales of the overlying Upper Devonian New Albany Shale. These Middle Devonian shales contain dolomites, dolomitic shales, gray shales, and thin black shale interbeds. The differences in lithology, faunal content, sedimentology, and geographic occurrence between the Middle and Upper Devonian shales is probably related to structural activity of the Cincinnati Arch and Kentucky River Fault System during Late Devonian time. This study shows that these structures may have a major control on the deposition, composition, and distribution of black shales and related facies in this area. This information will be used for mineral resource assessment in the Illinois Basin. A paper on the topic was presented at the Eastern Oil and Gas Shale Symposium at Lexington, Kentucky, in November 1990.

**Distribution of the Caseyville Formation in the Subsurface of the Illinois Basin Coal Field**, *Jacobson* The primary purpose of this study is to determine the subsurface distribution of the typical Caseyville lithology as recognized in the outcrop areas of southern Illinois. This lithology is characterized by thick quartz arenites with common quartz pebbles. At the base of the Caseyville is a major unconformity, representing a period of prolonged erosion that created a system of valleys now filled with Caseyville sediments. This sequence is important for understanding the distribution of oil and gas as well as coal resources.

At this time, five cross sections have been constructed in a seven-county area of southern Illinois. Most of the records used were electric logs; sample studies were utilized in conjunction with the logs. A database of subsurface drill-hole information was set up on a Sun workstation. The first set of drill holes for the database were selected and analysis of the lithologies present began.

**A Common Formational Nomenclature of the Illinois Basin for the Pennsylvanian**, *Jacobson, Weibel, Nelson, Damberger, Peppers* During the period, the three state geological surveys and geologists from industry and academia active in the Illinois Basin continued work on final agreements to standardize formational nomenclature for the Pennsylvanian System. This is part of an effort to simplify and systematize the Pennsylvanian stratigraphic classification in the basin. A manuscript presenting the standardized nomenclature is undergoing final revision.

**Study of the Nature of the Pennsylvanian-Mississippian Boundary,** *Weibel and Norby* A detailed study of microfossils and stratigraphy of the strata straddling the Mississippian-Pennsylvanian boundary in southern Illinois was undertaken. Samples of the oldest Pennsylvanian Wayside Member of the Caseyville Formation and the youngest Mississippian Grove Church Shale were processed for extraction of microfossils. These fossils, primarily conodonts, were used as a database in the reevaluation of the biostratigraphy. The sedimentary structures and textures of the core were studied to determine paleoenvironmental conditions. Results show several disconformities in the boundary interval. At the study site, the unconformity at the Mississippian-Pennsylvanian boundary is a minor disconformity. The proceedings of an invited paper are being published by the Oklahoma Geological Society.

**Biostratigraphic Correlation of Pennsylvanian Cyclothems from Midcontinent to Texas to Illinois,** *Weibel (ISGS); Heckel and Lambert (University of Iowa); Barrick and Boardman (Texas Tech University); Watney (Kansas Geological Survey)* The biostratigraphic study of stratal units in the context of sequence stratigraphy provides potentially a method of correlating units between different basins on the North American craton. It was found that conodont stratigraphy, supplemented by fusulinids and ammonoids, allows correlation of the major eustatic cycles from Texas to the Midcontinent to the Illinois Basin. Findings were presented at the 1991 annual meeting of AAPG.

**Sequence Stratigraphy of Upper Pennsylvanian Strata, East-Central Illinois,** *Weibel* The current stratigraphic classification of Upper Pennsylvanian strata is based upon key bed (limestone) boundaries. Application of sequence stratigraphy, using a modified cyclothem (a genetic sequence), has strong potential for a basinwide lithostratigraphic classification. Studies indicate that the classification of Upper Pennsylvanian strata based on sequence stratigraphy is not entirely compatible with the current, key-bed bounded classification, but aspects of both could be incorporated into a basinwide classification. Findings were presented at the 1991 North-Central Section meeting of the Geological Society of America.

**Paleoenvironmental Studies**

**Oakland Concretions from the Energy Shale,** *DeMaris and Moore* This project will combine evaluations of the flora, geochemistry, and mineralogy of concretions in the Energy Shale of the Oakland Site in east-central Illinois. These data are important to Illinois because a significant part of the relatively low-sulfur coal resources of the state are associated with it the Energy Shale. Initial geochemical data are nearly complete and plans have been made for detailed examination of selected concretions. Concretion processing for fossil flora continues; only plant fossils and driftwood have been found to date.

**Fusain Lenses in the Herrin Coal,** *DeMaris* Large, relatively pure fusain (porous, sooty portion of coal) lenses have been seen in four mines around the Illinois Basin suggesting these are widespread, rather than local features, in the Herrin Coal. Research is underway on the nature and in-seam stratigraphy of these lenses and the evidence for environments that they contain. Eight new full-seam descriptions have been completed, and ten samples of fusain have been collected for planned petrographic analysis.

**Tradewater Working Group of the Illinois Basin Consortium,** *Devera, Nelson, others* The first meeting of the group was held in Henderson, Kentucky on January 11, 1991. The meeting was held to organize plans to understand the complex depositional settings within the Tradewater Formation. Ten people, representing the Illinois, Indiana, and Kentucky Surveys, the USGS, Southern Illinois University at Carbondale, and the Smithsonian Institution were present. The main purpose for this meeting was to target sources of funding to support the group's activities. Currently, an Annex to the Memorandum of Understanding to the Illinois Basin Consortium Tradewater Working Group is being drafted.

**Synthesis**

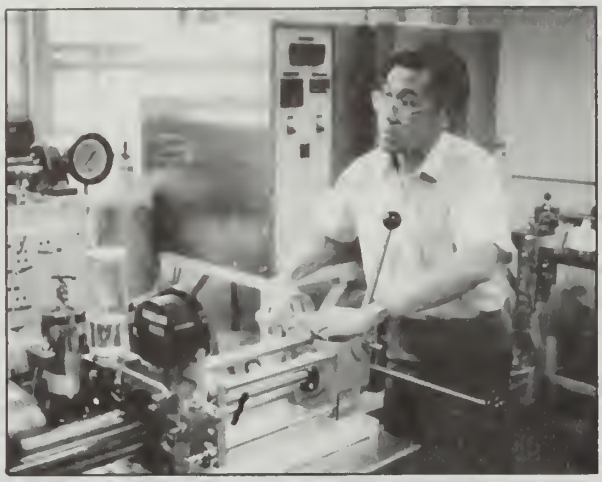
**AAPG Interior Cratonic Basins Volume,** *Leighton, Kolata, Oltz, Eidel, staff* In early May the American Association of Petroleum Geologists (AAPG) published Memoir 51, *Interior Cratonic Basins.* This is a major, comprehensive report on interior cratonic basins of the world. Half of the volume is devoted to the Illinois Basin as a prototype; the other half contains chapters on six other basins and a synthesis. The volume contains contributions from 62 geoscientists from the Illinois, Indiana, and Kentucky Geological Surveys, academia, and industry. Although considerable information is presented in the volume on the evolution of the Illinois Basin and other cratonic basins and their oil and gas fields, unanswered questions are also setting a course for future research.

**Illinois Basin Consortium** The Illinois Basin Consortium (IBC), consisting of the Illinois, Indiana, and Kentucky Geological Surveys, was organized in 1989 to develop a better understanding of the Illinois Basin through exchanges of information and cooperative basinwide studies. The consortium is coordinating efforts to avoid duplication of work and take advantage of facilities and expertise at the three State Geological Surveys. During the past year, a program plan was developed to help integrate and coordinate research activities.

The IBC also made substantial progress in its cooperative research with the USGS program, Evolution of Sedimentary Basins. The USGS began several projects in the basin that will focus on the fluid-rock interactions that have modified the basin through time.

**Evolution of Sedimentary Basins (ESB), a Cooperative Study Between the Illinois Basin Consortium (IBC) and the U.S. Geological Survey (USGS),** *Kolata (coordinator), staff* The Illinois Basin is one of six sedimentary basins that is the focus of the USGS Evolution of Sedimentary Basins Program. This program involves joint projects between the USGS and the IBC (Illinois, Indiana, and Kentucky Geological Surveys). During the past year, 12 projects related to fluid-rock interactions in the Illinois Basin have been initiated by the USGS. It is anticipated that these cooperative projects will lead to a better understanding of the nature and timing of fluid movement that resulted in migration of hydrocarbons, formation of ore deposits, and basinwide alteration of the sedimentary succession.

A



(A) Steve Sim, petroleum engineer, operates a positive displacement pump to increase the pressure of an oil and gas mixture. (B) While in the field working on the Cooperative Geologic Mapping Project (COGEOMAP), an ISGS scientist climbs a limestone outcrop along the Mlssissippl River in the Grand Tower area. (C) Organic chemist Joe Chou condenses pesticide extracts from water samples for a pilot study of agricultural chemicals in rural water wells. (D) Rob Krumm (center) and Curtis Abert (seated) of the Geologic Mapping and Digital Cartography Section explain computer mapping for landfill site screening to county officials.

B



C



D



### Technology Transfer and Information Services

**Workshop on Predictive Stratigraphic Analysis (PSA) in Lawrence, Kansas,** *Nelson, C. Treworgy and Weibel* This workshop was held on the initiative of the USGS, in support of a new research initiative on the Carboniferous geology on the North American plate. The workshop was attended by more than 50 representatives of the USGS, eight state geological surveys, and a number of universities. PSA is a new approach to stratigraphic analysis that involves development of predictive models that will enable geologists to locate new deposits of coal, oil and gas, and other mineral resources. Two narrow stratigraphic intervals have tentatively been selected for detailed study (Herrin Coal, Shumway Limestone) throughout the North American continent.

**Pennyrile Fault System,** *Lumm and Nelson (ISGS); Greb (Kentucky Geological Survey)* A manuscript, "Structure and Chronology of Part of the Pennyrile Fault System, Western Kentucky," has been accepted for publication in *Southeastern Geology*. This paper outlines the development of one of the major fault systems in the southern part of the Illinois Basin.

## QUATERNARY INVESTIGATIONS

Many mandated activities and state and contract supported projects conducted by the ISGS require comprehensive knowledge of the Quaternary (glacigenic) deposits that blanket most of Illinois. To provide the required information to better understand these deposits, the Quaternary Framework Section (QFS) has an ongoing program of (1) collection, organization, and evaluation of data; (2) updating of stratigraphic nomenclature and classification; (3) studies of glacial processes and environments of deposition; (4) framework development; (5) characterization of the various materials; and (6) mapping and development of mapping techniques and approaches. This program includes both basic research elements and projects tied to various programs and projects of other sections of the ISGS and overall State needs. Projects and studies related more specifically to mapping of Quaternary deposits are being coordinated with the Geologic Mapping and Digital Cartography Section.

### Framework Studies

**Quaternary Framework of the Lake Michigan Lobe Region,** *Hansel and others* Work on understanding the Quaternary sediment record and deglaciation history of the Lake Michigan Lobe continues. Establishment of radiocarbon age control and correlation of sediments and events in the region is a primary goal. Initial results were published in the *Canadian Journal of Earth Science and a Geological Society of America Special Paper* during this report period.

**Stratigraphy of the Quaternary Fill of the Middle Illinois Segment, Ancient Mississippi River Bedrock Valley,** *Väisänen and Kempton* This project was initiated during this period as the major research project of Ulpu Väisänen (exchange scientist from Finland) to correlate projects in the Mackinaw Segment to the south and in the Green River Lowlands to the northwest. A series of cross sections was developed based of logs and samples available. A preliminary report is in preparation.

**Quaternary Geology of the Martinsville Alternative Site,** *Curry, Berg, M. Cartwright (ISGS); K. Troost (Shannon and Wilson, Inc.)* Characterization of the Martinsville Alternative Site, a proposed low-level radioactive waste disposal site in Clark County, Illinois, has provided detailed information on the physical characteristics and distribution of a thick sequence of Illinoian glacigenic sediments that fill two large buried bedrock valleys. The sequence of sediments provides the framework for establishing and evaluating hydrological modeling and characterization, and will provide an important stratigraphic model for east-central Illinois. A paper on the genesis and continuity of sand and gravel deposits at the Martinsville Alternative Site was presented at the annual Geological Society of America meeting, and has been accepted for publication by *Environmental Geology and Water Resources*. Two open-file reports were released during the reporting period; it is anticipated that these reports will be combined and released as an ISGS circular during the following reporting period.

**Paleolimnology and Paleoclimate of the Southwestern Great Lakes Region,** *Curry and Follmer (ISGS); W. H. Johnson (UIUC): R. M. Forester (USGS); A. J. Smith (Kent State University)* Analysis of ancient lake sediments and fossil ostracodes (limnic crustaceans sensitive to water chemistry, depth, and temperature) are being studied to understand the effects of paleoclimatic change on ancient lakes. A database is being compiled of modern ostracode species and their abundance in lakes and ponds in Illinois and elsewhere in the midwestern United States; the database will allow interpretation of

ancient lake systems. Initial results have been presented at the North-Central Geological Society of America meeting and in the guidebook for the Friends of the Pleistocene field conference.

**Electron Spin Resonance (ESR) Ages of Sangamonian Mammal Teeth and Gar Scales at Hopwood Farm, Illinois,** *Curry (ISGS); B. Blackwell (Purdue University); H. Schwarcz (McMaster University); Saunders (Illinois State Museum)* Electron spin resonance techniques have been used to determine numerical ages for Sangamonian fossils, including gar scales, at Hopwood Farm, Illinois. Numerical ages are primarily dependent on the uranium-uptake rates used to model the internal and external dose rates to the sample. The most reliable analyses are from a mastodon tooth; results indicated the tooth is between 75 and 130 thousand years old. Results were presented at the annual meeting of the Geological Society of America; a manuscript is being prepared.

**Stratigraphic Studies of the Oldest Documented Quaternary Sediments in Illinois,** *Follmer (ISGS); B. Miller (Kent State University); R. Graham (ISM)* Preliminary studies have revealed that a silt deposit overlying the limestone at the County Line (Adams/Hancock) Section is about 800,000 or more years old. Recent work verified that the silt underlies a pre-Illinoian till (formerly classified as Kansan) that advanced across Iowa. A strongly developed soil (Yarmouth Geosol) has greatly modified these sediments in the accretionary deposits overlying the till. This ancient soil formed during an interval from about 300,000 to 500,000 years ago when the climate was as much as 10° F warmer than the current average. New collections from the old silt have yielded more types of fossils, including teeth from extinct species of rodents. Magnetic measurements on samples from the silt indicate sedimentation occurred when the earth's magnetic field was reversed (more than 700,000 years ago). Stratigraphic studies such as this provide age information on sediments, soils, and fossils and document a global climatic cycle of about 100,000 years. These studies form a basis for predicting the impact of future climate changes.

**Loess Research in the Lower Mississippi River Valley,** *Follmer and others* A proposal has been submitted to the Louisiana State University Board of Regents Louisiana Stimulus for Excellence in Research (LaSER) Program funded by the National Science Foundation. The purpose is to examine key stratigraphic sections of loess along the Mississippi River for comprehensive analysis of paleoclimate evidence and related parameters to refine correlations between Louisiana and Illinois. The proposal was initiated by Dr. W. Autin of the Louisiana Geological Survey in collaboration with five colleagues from Illinois, Iowa, Ohio, and Tennessee.

**Quaternary Classification Revision,** *Hansel and others* A symposium paper on late Quaternary time classification in the Great Lakes region was presented at the North Central GSA meeting in May 1991. A draft of a manuscript on the Wedron Group, a lithostratigraphic revision and reclassification of the Wedron Formation, is being reviewed and field tested. Selection of reference sections is underway.

### Quaternary Environments and Processes

**Field Evaluation of the Deformable Bed Model,** *Hansel (ISGS); W. H. Johnson (UIUC); P. U. Clark (Oregon State University); R. B. Alley (Penn State University)* Work on understanding and modeling the dynamics of the Laurentide Ice Sheet continues for the purpose of determining to what extent deforming beds controlled glacier flow, erosion, and sediment transport and deposition in the Lake Michigan Lobe ice stream in Illinois.

**Liquefaction Features in Glacial Fluvial and Lacustrine Deposits of Southeastern Illinois,** *Su, Curry, Follmer, Masters* ISGS is collaborating with Steve Obermeier (USGS) to support a field survey to locate potential earthquake-induced liquefaction features in the major tributaries to the Wabash and Ohio Rivers in southeastern Illinois. At several locations, investigators have found dike features that could have been formed by seismic liquefaction. If the features are seismic-induced, they may be related to the 1812 earthquake; but some evidence indicates they may be older. The ISGS has dated a piece of wood from one site near Wayne City at 2,250 ±70 years B.P. The wood sample rests on a truncated, sand-filled dike. Some features have been found as far north as Newton, Illinois, along the Embarras River. Stratigraphic analysis of the key sites is needed to work out the sedimentary history of region, and additional work is needed to determine whether the features were caused by an earthquake.

### Technology Transfer and Information Services

**Genesis and Continuity of Quaternary Sand and Gravel Deposits at a Proposed Low-Level Radioactive Waste Disposal Site Near Martinsville, Illinois,** *Curry* The ISGS, in cooperation with contractors working with the Illinois Department of Nuclear Safety, has developed the stratigraphic

framework and environments of deposition for Quaternary glacigenic sediments at the Martinsville Alternative Site. Kathy Troost of Shannon and Wilson, Inc., and ISGS staff presented a paper on the nature of sand and gravel deposits at the site to the annual meeting of the Geological Society of America in Dallas, Texas. The paper will be published by *Environmental Geology and Water Resources*.

**Quaternary Deposits along the Lake Fork Sangamon River near Pana, Illinois,** *Curry* In cooperation with the Illinois State Museum, the ISGS explored the area along the Lake Fork Sangamon River for paleontological/archeological sites that might be impacted by proposed roadwork. No fossils were found. An unpublished report was submitted to the museum documenting the stratigraphy, particle-size distribution, and clay mineralogy of sediments from two cores.

**Scientific Exchange with the Geological Survey of Finland,** *Hansel (ISGS); U. Väisänen (GSF)* During the 6-month exchange period, Hansel learned about and participated in the Quaternary mapping program in northern Finland and research on interglacial fossil soils in southern Finland; attended four international field conference meetings in Finland and one in Austria; reviewed the Mid-Norden Field Guidebook and various papers and abstracts; and gave talks at the GSF and the University of Stockholm. While at the ISGS, Väisänen participated in subsurface stratigraphy and groundwater research projects in central Illinois; field studies around the state and drilling in northeastern Illinois; attended the GSA annual meeting in Dallas; and presented a talk on her work in **Finland** at the ISGS.

**Technical Assistance to Fermi National Accelerator Laboratory,** *Kempton, Herzog, Bauer* Dr. W.B. Fowler of Fermilab requested that the ISGS assist Fermilab in developing geologic and geotechnical information for the design of the Main Injector Project (Fermilab III). After a series of meetings, the ISGS provided preliminary recommendations for additional test drilling and piezometer installations, and at the November 1990 meeting at Fermilab, agreed to submit a proposal for work in the future. As a side issue to the Main Injector Project, a brief report was submitted to Mr. Louis Kulu of Fermilab, at his request, describing the geology at the sites of three beam tunnels that have been proposed for attachment to the Main Injector.

**Geotechnical Site Investigation, 7-GeV Advanced Photon Source, Argonne National Laboratory,** *Killey and Trask* The final report of this project was compiled for publication by the ISGS. A field trip including the site for the advanced photon source was organized for the 1991 Annual Meeting of the Association of Engineering Geologists in Chicago.

**Working Conference on Global Climate Change,** *Follmer* A working conference on geological perspectives of global change was held by the International Union of Quaternary Research and UNESCO at Marseille, France, in September 1990. The 15 members, including Dr. Follmer, represented ten countries focused on the present and future research to address global change phenomena that could effect global climate and agricultural patterns. The group will prepare a document on the scope of contributions the Quaternary researchers of INQUA can make to the International Geosphere and Biosphere Program. Exchange programs to facilitate a global perspective were considered high priority; representatives from USSR and Hungary requested the ISGS to develop a Quaternary study exchange with their institutes.

**Paleopedology Symposium,** *Follmer (ISGS); D. L. Johnson (UIUC)* The Paleopedology Commission of the International Union for Quaternary Research has approved a plan for a symposium on paleopedology (soil) research problems and applications to global climate change. A 4-day symposium with a 6-day excursion will focus on causes and solutions to research problems and methods to resolve details about the impact of past climatic changes on soils. International experts will be invited to seek out the recent advances in technology and identify the common problems. Tentative plans are to hold the symposium at the UIUC Allerton House in 1993.

**Presentation of Invited Paper at International Symposium on Loess,** *Follmer* An invited paper, "Loess Research in the Mississippi Valley Region of the United States," was presented at the International Symposium on Loess at Mar del Plata, Argentina, November 25-December 1, 1990; Dr. Follmer also participated in a study tour of the geology, soils, and land use of the Pampas region of Argentina, December 2-10, 1990. From December 10-18, he visited universities in Sao Paulo and Florianopolis, Brazil, to examine their soil geomorphology work and discuss research methods.

**Technical Assistance to Soil Conservation Service (SCS), Lower Kaskaskia Watershed,** *Follmer* The SCS has requested assistance in the design of a field study on the soils developed in or above the glaciofluvial deposits of the lower Kaskaskia watershed. Dr. S. J. Indorante, project leader, is coordinating a major study supported by the National Soil Survey Laboratory to examine the relationships between geologic units and soil survey map units. To serve the growing demand for soil information, the SCS is updating soil interpretations in the region and preparing to expand the database for mapping at a larger scale. Test drilling and other related studies of parent materials will be conducted. The ISGS will assist in the classification and correlation of the geologic materials.

**Lithostratigraphy in Northeastern Illinois,** *Hansel, Killey, Barnhart, staff (ISGS); J. Jenson (Oregon State University)* Lithostratigraphy and glacial sedimentology were discussed at the Lemont type section on March 21, 1991. Hansel and J. M. Masters also led a field trip on lithostratigraphy in northeastern Illinois for the ISGS Geological Mapping and Digital Cartography Section in June 1991.

**Educational and Public Outreach Opportunities for the Professional Geologist,** *Killey* At the request of the Illinois Department of Conservation, a geologic framework report was prepared for Red Hills State Park in Lawrence County, Illinois. A report was also prepared on possible effects of a sand and gravel mining operation on the water level of a nearby lake in McHenry County.

**Quaternary Materials Lab,** *Miller* Particle-size analyses were completed for 456 samples under a contract with the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory.

## BASIC AND FUNDAMENTAL HYDROGEOLOGIC INVESTIGATIONS

Hydrogeologic investigations at the ISGS are undertaken primarily by the Hydrogeology Section, the Groundwater Protection Section (formerly the Groundwater Resources Section), and the Hydrogeology Research Laboratory; however, related work is undertaken by other sections. Studies focus on developing and protecting the state's groundwater resources. This is accomplished through basic research into hydrogeologic processes; applied studies in groundwater development, groundwater assessments, and impact of waste disposal on groundwater quality; and technical services supporting the water-use and environmental-information needs of the general public, industry, and other governmental agencies. Included in this section of the Annual Report are those elements considered as fundamental or basic research.

### Hydrogeology Processes

**Natural Recharge of Groundwater in Illinois,** *Hensel* Infiltration of precipitation that falls on land surface and the natural recharge of the groundwater system are different but related hydrological processes. Recharge is the portion of infiltrating water that enters groundwater. A report describing infiltration and recharge processes and how these processes occur in typical Illinois hydrogeologic terranes has been completed and is in preparation for publication in the ISGS Environmental Geology series.

**Study of Transit Time Through Compacted Clays**, *Cartwright, Krapac, Herzog, Panno, Hensel, Rayfield* This study, funded by both the U.S. Environmental Protection Agency (USEPA) and the Hazardous Waste Research and Information Center, began in 1985; USEPA funding will end in September 1991, and HWRIC funding ends January 1992. Additional FY 91 funding has been received from HWRIC during this period. A grant application is being prepared for the USEPA to continue monitoring the field-scale liner located on the campus of the UIUC and to conduct new experiments.

Compacted soil liners are widely used at landfills and waste lagoon facilities for containment of leachates and liquid wastes. The liner functions as a barrier between the waste materials and the hydrogeologic environment by limiting seepage from those facilities. When the landfill or lagoon contains hazardous wastes, the facility is required to have a double liner system, a leachate collection and leak detection system, and two flexible membrane liners—all underlain by a compacted soil liner. In Illinois, recently enacted regulations for municipal refuse disposal requires that the landfill have a 1.52-meter-thick compacted soil liner or a composite liner consisting of a geomembrane and a 0.91-meter-thick soil liner. In landfilling of either hazardous or municipal wastes, the soil portion of the liner must have a saturated conductivity of no more than $1 \times 10^{-7}$ cm/s.

The final part of the study that began in April 1988 consists of monitoring the $8 \times 15 \times 0.9$ meter field-scale soil liner. During 3 years of monitoring the soil liner, there have been no significant changes in the

infiltration fluxes or gradient. Depending on the type of monitoring instrument, measured infiltration fluxes range from 8.1 to 1.5 x $10^{-8}$ cm/s. During the third year of monitoring, an increase in the fluxes has been recorded by the large-ring infiltrometers, which presented some problems in previous years, so that these fluxes are now closer to those fluxes measured by the small-ring infiltrometers and water balance. The average gradient in the liner is approximately 1.9, as recorded by pressure-transducer tensiometers located at various depths within the liner. All calculated values of saturated hydraulic conductivity of the liner are significantly less than 1 x $10^{-7}$ cm/s. The wetting front is estimated to be about 55 cm, 3 years after initiation of the final experiment; this amounts to about 62 percent of the liner thickness. The earliest estimate for water exiting the bottom of the liner, based on a linear projection of the water balance data, is mid-1992.

Specific objectives of this study were

- determine whether the USEPA requirement of a saturated hydraulic conductivity of 1 x $10^{-7}$ cm/s or less can be achieved as measured in situ;
- quantify the areal variability of liner hydraulic properties;
- determine the transit times of water and tracers through a compacted soil liner—that is, determine when breakthrough of water and contaminants will occur;
- test the accuracy of methods for predicting the transit time of water and tracers through the liner.

The present study has provided data to achieve objectives 1, 2, and 4; however, the determination of actual transit times and the formulation of improved methods for predicting transit times awaits the new grant for completion.

### Hydrogeology Research Laboratory Studies

The ISGS Hydrogeology Research Laboratory (HRL) was created to conduct research into fundamental problems of hydrogeology and to facilitate applied research and service programs. Activities are conducted by HRL staff and cooperatively with other ISGS sections. Currently the HRL is focusing on groundwater and chemical movement in low-permeability rock and sediments, large-scale basin groundwater flow, groundwater recharge/discharge relationships of wetlands, and recharge to productive aquifers. Progress is being made in renovating the HRL in room 435 of the Natural Resources Building.

### Field Laboratory Studies

**Potential Impacts on the Hydrology and Ecology of a Pristine Fen Resulting from Intrawatershed Development**, *Cartwright, Hensel, Panno* This project, which began in July 1990, is funded by the Water Resources Center at UIUC and the Illinois Department of Energy and Natural Resources (ENR).

Identifying and evaluating the impact of watershed development on the vegetation and hydrology of the fen and associated wetland in Crystal Lake, Illinois, will be the basis for determining what, if any, options may be used to minimize the adverse effects of urbanization on the wetland complex. Water chemistry data are being used in conjunction with hydrogeological and biological data. Preliminary results have shown that the fens are the discharge areas for groundwater in the watershed. Changes in groundwater have been shown to affect the composition of the fen vegetation, which is highly dependent on groundwater. For example, the effect of groundwater changes on the fen can be seen in one area where elevated concentrations of Cl, Na, and $No_3$, possibly resulting from a nearby septic discharge, have created conditions that promote cattail growth to the detriment of fen species.

**Groundwater Chemistry of the Mahomet Valley Aquifer in East-Central Illinois,** *Panno, K. Cartwright, Liu, Hackley, Heidari* Determining the patterns of groundwater circulation in the Mahomet Valley Aquifer, chemical characteristics, sources of chemical constituents, sources of recharge to the aquifer, and the ratio of recharge from surface and bedrock are the objectives of this research. Preliminary groundwater sampling and analysis has been completed. Additional water chemistry data on the groundwater of the Mahomet Valley Aquifer have been obtained from the groundwater quality database at the Illinois State Water Survey. More than 1,000 analyses have been evaluated. These data will be useful in defining areas where additional and more complete water chemistry data will be beneficial to the investigation.

## PALEONTOLOGY/PALYNOLOGY INVESTIGATIONS

Paleontology and palynological investigations focus on the use of information from fossils to date rock units, correlate these units, and determine the environments of deposition of the rock. Age information

is beneficial for locating oil and gas, coal, and industrial minerals. Several palynological (fossil spores and pollen) studies have concentrated on correlating Pennsylvanian coal strata within the Illinois Basin. A major palynological study involves correlating Pennsylvanian chronostratigraphic boundaries in the Illinois Basin with other major coal regions. A paleontology study focused on selected Mississippian microfossil species and their value in correlating strata.

Additional responsibilities include collecting paleontologic/palynologic material from important fossiliferous rock exposures and cores to supplement the extensive ISGS data collection and to determine the evolution and relationships of various fossil groups.

The paleontologic/palynologic database collections often provide needed information required to solve geological problems without time-consuming new studies. The *Guide to Pennsylvanian Fossil Plants of Illinois* (ISGS Educational Series 13) is one project that benefited from the database collection. This booklet has been well received by the general public and the scientific community. The paleontologic database was also valuable in assembling a scientific short course presented at the 1990 Geological Science of America meeting.

### Paleontology Studies

**Taxonomic Study and Biostratigraphic Significance of the Mississippian Conodont Genus *Lochriea*,** *Norby (ISGS); von Bitter (Royal Ontario Museum, Toronto)* This study redefines the Mississippian conodont genus *Lochriea* and makes it more useful as a biostratigraphic indicator. Several species, which will now be classified under this genus, have become important in several international biostratigraphic charts. These species, however, were not well understood because the constituent elements of each species were misidentified. A manuscript with seven photographic plates has been completed and submitted to the *Journal of Paleontology.*

**Ichnofossil Research,** *Devera* Additional trace fossils were collected and curated. More than 250 specimens have been identified from the southern Illinois bedrock outcrop belt of Pennsylvanian strata. This project will be expanding both stratigraphically and geographically as the COGEOMAP mapping continues southward into Union and Alexander Counties.

### Palynology Studies

**Correlation of the "Boskydell" Sandstone in the Lower Middle Pennsylvanian in Southern Illinois by Use of Palynology,** *Peppers* The name "Boskydell" Sandstone was first used for a sandstone in Jackson County; it is distinctive because it contains marine fossil shells. Since then, other fossiliferous lower Middle Pennsylvanian sandstones have been called "Boskydell" Sandstone. The purpose of the study is to determine the ages of the reported occurrences of "Boskydell" Sandstone by using palynology of coals above and below the sandstones. It has been found that the fossiliferous sandstone near the town of Boskydell is a little younger than the Rock Island Coal or its equivalent. Other "Boskydell" sandstones, which are of three different ages, are older than the sandstone at the type area. It was recommended that the name "Boskydell" be discontinued and that fossiliferous sandstones should be referred to as a marine facies of a particular sandstone. A manuscript is undergoing internal review.

**Implications of Major Floral Changes at the Middle-Upper Pennsylvanian Boundary,** *Peppers* The paper, "Major Floral Changes at the Middle-Upper Pennsylvanian (Westphalian-Stephanian) Boundary in the Euramerican Coal Belt—Response to Gradual Climatic Change or Extraterrestrial Phenomenon?" was completed and is undergoing internal review. The paper is an outcome of the larger study on the palynological correlation of major Pennsylvanian chronostratigraphic boundaries; it includes a discussion of the possible causes of the most pronounced change in coal swamp floras during the Pennsylvanian at the Middle-Upper Pennsylvanian boundary. Some researchers have proposed that the apparently sudden change is due to missing strata at an unconformity. The paper concludes that the changes were due to major glaciation in the southern hemisphere, which resulted in seasonal drying and changes in wind and water currents. The Gondwana landmass drifted northward, causing climatic changes. A decline in atmospheric carbon dioxide was especially harmful to the physiology of large trees growing in the coal swamps. There is no evidence for a catastrophic event similar to that which occurred at the Cretaceous-Tertiary boundary and may have been partly responsible for extinction of the dinosaurs.

**Palynology of Samples from Potential Low-level Nuclear Waste Storage Site Near Jeff, Wayne County,** *Peppers and Lowry* The palynological contribution to the study of the Jeff site was completed. Several surface and core samples of coal were examined for age determination to aid in the stratigraphic

study and report by Richard Berg and Pius Weibel. Samples of coal from a core drilled near Charleston were studied to help correlate the strata from Charleston to the geologic section at the Jeff site.

**Palynological Correlation of the Dawson Springs Coal Bed and Equivalent Coal Beds in the Illinois Basin,** *Peppers and Lowry* This study correlates the Dawson Springs Coal, which has been extensively mined in western Kentucky, with several other coals in Kentucky, a coal in southern Illinois, and the Buffaloville Coal in Indiana. The coal is thus more widespread than previously thought. It is early Desmoinesian in age and younger than the Rock Island Coal. Coal samples from 32 locations are being studied. Miscorrelation of an overlying limestone has led to misidentification of the Dawson Springs Coal at some localities.

**Working Group of the Middle Pennsylvanian Commission of the International Geological Union,** *Peppers and Lowry* Palynological contributions to the commission continue on an informal basis. Several Missourian and Virgilian Coal samples from the Midcontinent were submitted to find out whether Virgilian spore assemblages are significantly different from Missourian assemblages.

**Technology Transfer and Information Services**

**SEPM Working Group of the Middle Pennsylvanian,** *Peppers and Lowry* A report on the analysis of coal samples collected during the 1990 SEPM Working Group field trip was prepared and sent to the members. The most important discovery was that several coals thought to be Atokan in age are Desmoinesian in age. The Atokan-Desmoinesian boundary apparently is being placed higher than it is at the type area of the Atokan.

**Arthropod Fossil Record,** *Mikulic* Arthropods are an important group of invertebrate animals characterized by jointed appendages and segmented bodies. Ancient trilobites and modern insects both belong to this group. The paper, "The Arthropod Fossil Record: Biological and Taphronomic Controls," was presented orally and published as part of a Paleontology Society short course on arthropods. Dr. Mikulic was also a coauthor of a second paper prepared for the short course, "Temporal Patterns of Arthropod Trace Fossils."

The short course on arthropods was held in conjunction with the Geological Society of America Annual Meeting in Dallas, Texas, in October 1990. Dr. Mikulic organized the 1-day short course, selected the 14 speakers, and served as convener and chairman. There were approximately 200 participants.

**Temporal, Ecological, and Environmental Trends in Phanerozoic Soft-Bodied Fossil Lagerstatten,** *Mikulic (ISGS); Kluessendorf (UIUC)* Much knowledge of the character and evolution of Phanerozoic life forms is based on exoskeletal remains (hard parts). The remains of soft-bodied organisms are rare, and when discovered, greatly interest paleontologists. A poster session in the topic was presented at the Annual Meeting of the Geological Society of America in Dallas, Texas, in October 1990.

**Palynological Correlation of Major Pennsylvanian (Middle and Upper Carboniferous) Chronostratigraphic Boundaries in the Illinois Basin with Those in Other Coal Regions in the Equatorial Coal Belt,** *Peppers* The final draft of this long-term study has been undergoing review during the report period. The paper will be submitted to an outside journal. The study is a comprehensive palynological correlation of Pennsylvanian stratigraphy.

**Comprehensive Survey of the ISGS Paleontological Collections,** *Norby* At the request of Dr. Thomas Uzzell, director of the University of Illinois Museum of Natural History, a comprehensive survey of the ISGS paleontological collections began. The survey will include details on the size of the collections (number of types), composition (major groups, geographic areas, synopsis of major collections), space utilized, availability of collections, curatorial status (fraction of collection catalogued), and collection use. This survey, requested of all collection managers, will enable the Director to be the initial contact (clearinghouse) for information on collections at the University of Illinois. The new director, Dr. Daniel Blake, appointed during this period, has made a personal request for these same data.

**Paleontological Collections,** *Norby* The ISGS made loans of type fossil material to researchers from seven academic or research institutions in the United States, Canada, England, and Australia.

## GEOCHEMICAL INVESTIGATIONS

Geochemistry, the union of geology and chemistry, covers a broad field extending into such areas as microbiology and atmospheric studies. Geochemical research is included in all ISGS research areas. Much of it is described under the program in which it is applied. A few geochemical studies that are basic in nature or involve one or more programs are described below.

### Coal Geochemistry

**Synchrotron X-Ray Fluorescence Microprobe Study of Trace Elements In Cleat Calcite of Illinois Coals,** *C.-L. Chou (ISGS); A. Kolker (University of Nebraska)* Analyses for trace elements in cleat- or vein-filling calcite in the Herrin, Springfield, and Colchester Coals were made using the synchrotron X-ray fluorescence microprobe at the National Synchrotron Light Source of the Brookhaven National Laboratory. The analyses revealed considerable variation in the microdistribution of manganese (786 to 9,480 ppm), strontium (<5 to 461 ppm), and iron (52 to 16,700 ppm), the most abundant minor and trace elements present. In nearly all the samples, a high iron (>~5,000 ppm) calcite is the latest calcite to form, replacing earlier generations with varying but generally lower iron contents. Trace-element concentrations in the basinal fluid from which this late calcite precipitated were calculated using the elemental concentrations in calcite and calcite/fluid exchange distribution coefficients. The Mn/Ca, Fe/Ca, and Sr/Ca ratios of the basinal fluid differ significantly from seawater and deep basin brines, but are within the range of present-day meteoric formation waters. Thus, it is postulated that cleat calcite results from the migration of meteoric groundwater in the basin.

### Shale Geochemistry

**Geochemistry of Black Shales in the Illinois Basin: A Review of Recent Literature,** *C.-L. Chou* Recent advances in the geochemistry of black shales in the Illinois Basin were reviewed. The published data show that systematic variations of pyritic sulfur, degree of pyritization, and amount of carbon in New Albany Shale Group (Devonian-Mississippian) are related to the environments of shale deposition. Pyrite is formed during early diagenesis of shales; however, in shales highly enriched in organic carbon and trace metals, there is a lack of correlation between sulfur isotopic composition and organic carbon, suggesting that the pyrite was precipitated syngenetically near the sediment-water interface in an euxinic environment. A paper on this subject will be presented at the 1991 Eastern Oil Shale Symposium.

## MINERALOGICAL INVESTIGATIONS

ISGS mineralogical research emphasizes (1) methods of analysis and the maintenance of a world-class laboratory for mineral studies; (2) studies of clay and related resources; (3) studies of clay minerals that affect other ISGS programs, such as the effect of clays on oil recovery; and (4) basic investigations that extend knowledge of clay minerals with emphasis on soils. Studies of clay minerals in soils have been undertaken to help reconstruct the paleogeography and paleoclimates of ancient soils, predict the suitability or capacity of materials for the isolation or absorption of hazardous wastes, indicate areas of geotechnical hazard or stability, and evaluate soils for clay products, agriculture, and other uses such as pond liners.

The Clay Mineralogy Unit supports a wide range of projects within the ISGS and assists the public, industry, government, and academic community. Mineralogical analyses inform landowners about the value of earth materials on their properties, identify changes in minerals that affect the recovery of mineral resources, and contribute to the solution of environmental problems such as siting waste disposal facilities. Upgrades of the computer operating system for the Scintag X-ray diffraction system for the Illinois Improved and Enhanced Oil Recovery Program have led to improvements in the quantitative analysis of minerals and synthetic substances—improvements that will affect every area of ISGS research and service. Applied mineralogical studies continue on a recent kaolin or ball clay discovery; they have also resulted in detection and remediation of coal mine stability problems, procedures for extracting oil, and location of clay resources for Illinois industries.

Basic research led to the recent discovery of the rare clay mineral berthierine in Native American artifacts from Illinois. Its association with kaolin deposits and the oolitic iron-oxide facies of a shale have led to studies to refine knowledge of the origin and mineralogical structure of berthierine.

Advice, consultation, and assistance to approximately 20 graduate students in Illinois universities by Clay Unit mineralogists is a further aspect of basic research in mineralogy. In many cases, these associations lead to significant new information.

## Research Studies

**Soil Clays,** *Hughes, Moore, Glass (ISGS); Reynolds (Dartmouth College)* Soil-forming processes that result in distinctive changes in mineralogical composition are being investigated to identify mineralogical "signatures" indicative of particular soil types, record the intensity and duration of soil formation, and reveal similarities and differences between modern and ancient soil occurrences. The goal is to use knowledge of soils to reconstruct paleogeography, estimates changes in regional erosion and climate caused by European settlement, provide stratigraphic controls, and locate economically valuable mineral deposits. Recent efforts have shown that the variety and amount of kaolinite/smectite that forms is related to the duration of weathering. The paper, "The Nature, Detection, Occurrence, and Origin of Kaolinite/Smectite," by Hughes and Moore has been prepared for a special symposium volume, *Clays and Clay Minerals*; it has completed final review and been sent to the publisher.

**Quaternary Geology by Mineral Composition**, *Glass, Moore, Hughes* The mineral composition of Quaternary deposits and their associated soils is being used to reconstruct their depositional history. An invited paper on X-ray diffraction methods has been completed and will be published soon as a monograph of the Soil Science Society of America. Recent efforts have also been directed to the mineralogical characteristics that distinguish wet soils formed in place from eroded soils deposited in low, wet areas. A large effort has been directed at entering data from paper files to a computer database. An abstract has been submitted and accepted for a poster presentation on the correlation between the type and amount of clay minerals in soils and the length of weathering associated with the soil formation. This poster will be presented at the annual meeting of the Clay Mineral Society in Houston.

**Native American Artifacts Made from Berthierine in Whiteside County, Illinois,** *Hughes and Moore (ISGS); Berres (UIUC); Bish (Los Alamos National Laboratory)* The recent discovery of the rare clay mineral berthierine, a rare clay mineral with a structure similar to kaolinite, in Native American artifacts from Illinois and its association with kaolin deposits and the oolitic iron-oxide facies of a shale have led to studies to exploit this information and to refine our knowledge of the origin and mineralogical structure of berthierine. The refinement of the structure of berthierine is being carried out at Los Alamos National Laboratory.

Berthierine has been found to be the raw material for a wide range of Native American artifacts from northwestern Illinois. The occurrence of artifacts suggested that the area around Sterling, Illinois, was the geological source of this material. A sample from the Neda Formation near Sinnissippi Park in Sterling has been found to contain berthierine, kaolinite, and boehmite in similar proportions to many of the artifacts. This discovery proves that the Neda formation was the source of the raw material for the Indian artifacts. The source of these materials was previously thought to be near Portsmouth, Ohio. A major source in Illinois will change the perception of the value placed on these artifacts and of the pattern of their dispersal through ancient trade networks. The material is distinctive enough that it will be possible to identify it in existing collections.

A second site near Albany, Illinois, is being investigated to discover whether this site had a local source of raw material or was supplied by deposits near Sterling. Analysis of samples from the Albany and Sterling areas and construction of a database of existing information from the region were the principal activities of the past year.

## XRD Laboratory Improvements for Mineral Analysis

**Improved XRD Procedures,** *Hughes and Moore* Research during the report year focused on improved quantitative analysis of the mineralogical composition of clay-bearing rocks and minerals. A library of standard intensities for most of the common varieties of clay minerals was constructed, and the computer programming required to automatically calculate the composition of unknown clay minerals began. Recent progress has also been made using internal standards to improve quantitative analysis.

**Quality Assurance/Quality Control Procedures for Quantitative Mineralogical Analysis by X-Ray Diffraction**, *Hughes and Moore* Procedures for quality assurance/quality control (QA/QC) are being written for individual projects. Construction, verification, and secure storage of computer databases of all current and past results, the second step in QA/QC, began. Databases from the studies of proposed low-level nuclear waste sites and the Argonne National Laboratory site have been merged with the computerized records of the Clay Minerals Unit.

### Technical Transfer and Information Services

**Clay Minerals Presentations,** *Hughes and Moore* Five talks and poster presentations were given at national meetings. The talks reviewed new information about soil clays, clay mineral analysis, enhanced oil recovery, and berthierine and its use by Native Americans. A working seminar on soil mineralogy at Thebes was held with students and staff of UIUC. Most efforts with students and staff of several universities involved transfer of ideas, results, and suggestions on ways to solve their mineralogical problems.

## COMPUTER RESEARCH

Computer Research includes the development and optimization of the computing environment to support ISGS research activities and the application of computing tools to research problems. Computers and other hardware utilized for research activities include a Prime minicomputer; Sun, Vax, and Silicon Graphics workstations; pen and electrostatic plotters; film recorders; digitizers; graphics terminals; and other devices. These devices are linked via an Ethernet network within the Natural Resources Building, via the UIUC optical-fiber network and Internet to major computing centers around the nation, and via dedicated phone lines to ENR offices in Springfield.

The Geological Mapping and Digital Cartography Section, formerly the Computer Research and Services Section, is continuing its work in the construction and maintenance of tabular and graphic databases; in specialized software such as ARC/INFO, INFO, ISM, IVM, Oracle, Z-Map, programming languages, and assorted PC software; in computer system design; in software and hardware evaluation; in project design; and in the applications of computers to geoscience problems, particularly to the development of the Illinois Geographic Information System (IGIS). Recent research on the use of ISM/IVM and ARC/INFO to produce maps of subsurface geology for landfill siting has led to new approaches that provide workmaps and cross sections of large amounts of well data. These can reduce the manual manipulation of data and thereby improve the efficiency of analysis of large volumes of data. Future goals are to move all computing off the Prime 9955 and onto workstations, to expand communications via the building-wide network, and to further develop the computer systems for analysis and visualization of the subsurface.

### Programming and Data Entry Research

**Development of Computer-Assisted Cross-Section Construction and Analysis Tools,** *McKay, Pool, Abert* Refinement of ARC/INFO AML programs for drawing cross sections continued, culminating in a product that allows the geologist to select a set of well data, specify horizontal scale and vertical exaggeration, and plot an east-west or north-south section on the electrostatic plotter so that each well is placed in its proper horizontal and vertical position and displays descriptive lithologic information. In an editing session on a computer workstation, the geologist can view color-coded lithologies and descriptive information and assign stratigraphic correlations. These data are then easily output to software for calculating contour surfaces and isopachs. The procedures were developed and tested on a 6,000 well database in Lake County.

**Programming for a Computerized Grinding Mill,** *Khan, Gurmen, Witzany* During the past 2 years, a computer program was written and maintained to permit the investigation of means of achieving energy savings during comminution of mineral products through the use of a laboratory-scale tumbling rod/ball mill. A personal computer was used to interface with sensors and transducers. The computerized mill provided an opportunity to examine the impact of the motion of the grinding media and of the design and configuration of internal lifters on the consumption of energy and the nature of product that was generated. An additional program was written this year to perform basic statistics on the data.

### Computer Systems

**Microcomputer System Design, Setup, and Troubleshooting,** *Witzany, Riley, Yeko, Lecouris, others* Continued assistance was provided to many ISGS staff members in the last fiscal year to support the nearly 200 microcomputers used at the ISGS. This service included the design, acquisition, and installation of microcomputers, the installation of and basic training in the use of software packages, and the upgrading and troubleshooting of other microcomputers. Virus removal and prevention services were also made available.

**Communications System Setup and Troubleshooting,** *Witzany, Wilson, Riley* Numerous ISGS staff members were assisted with the establishment, maintenance, and troubleshooting of their communications hardware and software, as many in the ISGS were connected to the Natural Resources Ethernet

backbone this fiscal year. Besides assisting with the initial installation of the Ethernet hardware and software, help was provided in using the Telnet program as well as in the use of the file transfer and mail programs available via the host computers.

### Technology Transfer and Information Services

**Geographic Information System (GIS) Demonstration, Workshops, and Training,** *Geological Mapping and Digital Cartography (GMDC) Section staff* Online demonstrations of GIS mapping capabilities have been presented to many individuals, including ENR Director Moore, and representatives from the Illinois Emergency Services and Disaster Agency, Southwestern Illinois Planning Commission, the U.S. Geological Survey, the U.S. Army Corps of Engineers, the Soil Conservation Service, Bradley University, University of Nebraska, Northern Illinois University, Southern Illinois University, the Indiana Department of Environmental Management, and numerous industries. GMDC staff also presented talks at many conferences including the national and regional ARC/INFO Users Group Meetings, the International Association for Impact Assessment, the Association of Engineering Geologists, the Central United Stated Earthquake Consortium, the Soil and Water Conservation Society, the Indianapolis GIS User Group, the Illinois Geologic Mapping Advisory Committee, the Champaign Hydraulic Engineers Association, the Illinois Rural Health Association, and the Illinois Mapping Advisory Committee. Three staff members from the Geological Mapping and Digital Cartography Section attended the International Arc/Info Users Conference in Palm Springs, California, and presented the papers, "Geologic Mapping and Modeling for Solid Waste Siting" and "GIS Applications for the Lands Unsuitable for Mining Program." In addition, staff presented the poster, "Multilevel GIS Applications at the Illinois State Geological Survey," which won second place in the Most Analytical category in competition against several hundred posters. This was the third consecutive year that ISGS posters won prizes at the meeting.

**NRIF Digital GIS Data Sales,** *McKay, Denhart, Krumm* Distribution of digital GIS data under the Natural Resource Information Fund are continuing to industry, federal agencies, county governments, and state agencies. The largest demand has been for the Lambert Conic Conformal Projection values for section corners throughout the state. Conversion of these data to state plane values is also available.

**County Letter-Size Work Maps,** *Junkins and Denhart* Work maps showing county, township, and section lines for each of the state's 102 countiese have been prepared, printed on a laser printer, and made available. These handy reference maps are used by ISGS staff to validate legal descriptions of well locations, for study area base maps, and as references for requests for digital data.

## SCIENTIFIC SUPPORT SERVICES

Few research or service projects can be successfully carried out by one team, section, or branch. Support of scientific programs requires a wide variety of services ranging from chemical and mineralogical analyses, to computer programming and maintenance, to review and publication of research findings.

During the year, continued emphasis was placed on enhancing our quality assurance/quality control (QA/QC) procedures. Despite the delays necessitated by the continuation of the ISGS laboratory upgrade program, significant improvements in analytical capabilities were made in several areas.

### Quality Assurance/Quality Control

**Quality Assurance Committee,** *Dreher, Harvey, Chaven, C-L Chou, J. Frost, Herzog, and Roy* Two questionnaires were developed to simplify the tasks of outlining proposed research projects and writing a project quality assurance plan. The questionnaires were discussed with section heads to show how quality assurance applies in various research aspects of the ISGS.

**Quality Assurance/Quality Control (QA/QC) Committee,** *Dreher and Harvey* Considerable effort was devoted to designing an outline and questionnaire as a guide for principal investigators to implement QA/QC for individual projects. Inherent differences between the various types of projects that are undertaken by ISGS scientists had to be accommodated. As a result, a flexible plan for QA/QC was designed and implemented in the two scientific branches. Section heads cooperated with identifying specific projects for which a Quality Assurance Plan would be prepared following the initial design. These "pilot" QA/QC plans are scheduled to be completed in mid-December of this year.

**Ad Hoc Committee on Sample Data Management,** *Harvey, R. Wilson, Dreher, Denhart, Chaven, Hensel, Su, Goodwin* The committee resolved certain difficult procedural problems regarding unique numbering systems for samples and the types of samples that will be entered into a new database for tested samples. Recommendations that covered the procedures and the implementation of the database were accepted by the management committee.

### Analytical Chemistry Services

Additional remodeling was started in some of the Analytical Chemistry laboratories. Operations in the instrumental neutron activation laboratory were fully restored with the purchase and installation of two ACCUSPEC 4096-8192 channel memory boards and the associated software for operation of two multichannel analyzers. These replace two analyzers that failed in 1990. New computer programs were written for batch operations of neutron activation analysis, and existing programs for reduction of the gamma spectroscopy data were revised to incorporate new formats and features from the ACCUSPEC systems. Alpha spectroscopy equipment, added through Build Illinois equipment funds, provides the capacity to determine lead-210 and uranium isotopes in sediment samples.

### Isotopic Geochemistry Services

**Isotopic Analysis Service Laboratory,** *Liu, Hackley, Riley, Hwang, Cao* During the report period, carbon and oxygen isotope analyses were completed on 602 samples, sulfur isotope analyses were performed on 342 samples, and D/H ratio determinations were conducted on 521 samples. Approximately 20 percent of these samples were for QA/QC and standardization purposes. Of the carbon and oxygen isotopic analyses, 35 percent were for research projects at UIUC, 25 percent were in support of the ISGS Radiocarbon Dating Laboratory, and 20 percent were in support of various ISGS research projects. Of the sulfur isotopic analyses, approximately 49 percent of the samples processed were for ISGS research projects; the others were analyzed for a research project at UIUC. Of the D/H ratio determinations, 29 percent were conducted for UIUC research projects, 23 percent were performed for ISGS groundwater research, and the rest were conducted for method development experiments. In addition to isotopic analyses, 96 quadrupole mass-spectrometric/pyrolysis-combustion experiments, and 460 acid-leach, LAH extraction, and high-temperature combustion runs were conducted on coal samples in support of ISGS projects on desulfurization and chlorine removal.

The development of a new procedure for determining $^{18}/^{16}O$ ratios for water samples using serum bottles for $H_2O$ - $CO_2$ equilibration has been successfully completed. A standard deviation of ±0.1‰ or better has been achieved for all three international standards, SMOW, GISP, and SLAP. Other tests designed to improve the extraction of sulfide sulfur from coal samples and the conversion of sulfide/sulfate into $SO_2$, using one oxidizer ($V_2O_5$) instead of two different oxidizers, were also conducted during the report period. The results of these tests have shown that zinc acetate can be used to replace the more toxic cadmium acetate completely during sulfide sulfur extraction, and $V_2O_5$ is very efficient in converting both sulfide and sulfate into $SO_2$ (average yield of 99 percent or more) for isotopic analysis.

In the same period, the Nuclide ratio mass-spectrometer underwent major repairs, including replacement of electronic parts in the magnetic regulator and installation of new capillary tubes and source filament. The ion source was dismantled and thoroughly cleaned to improve sensitivity.

**Radiocarbon Dating Laboratory,** *Liu, Wang, Coleman* Radiocarbon ($^{14}C$) age determinations are provided as a ISGS service to both the geological and archaeological community. During the report period, 115 radiocarbon age determinations were performed for scientists throughout the state of Illinois.

The Radiocarbon Dating Laboratory was invited to participate in the International Atomic Energy Agency (IAEA) $^{14}C$-intercomparison samples program during the report period. In the program, five unknown samples were distributed to more than 100 $^{14}C$-dating laboratories worldwide in an attempt to establish accurate $^{14}C$ ages for each of the five samples. The results of the program were announced by the IAEA during the 14$^{th}$ International Radiocarbon Conference, held on May 20-24, 1991, at Tucson, Arizona. Of the five $^{14}C$ analyses performed for this project, all were within 1 standard deviation of the IAEA's accepted values. Overall, the ISGS's and the IAEA's analytical results are statistically indistinguishable.

Upgrading the benzene synthesis vacuum system for $^{14}C$ sample preparation is underway. The newly designed combustion section of the system is now operational. A lengthy shutdown of the operation will be avoided by installing the new system section by section over approximately 6 months.

### Inter-Survey Geotechnical Laboratory

After about 7 years of operation, the Laboratory Steering Committee recommended that the Formal Operating Agreement be dissolved because of the lack of funding from contract users. The Chiefs of both the ISGS and ISWS agreed and signed the statement dissolving the operating agreement in December; the laboratory service account will be the sole responsibility of the ISGS. The laboratory will remain administratively within the ISGS Quaternary Framework Studies Section. It now operates under a new name, Quaternary Materials Laboratory.

### Computer Services

**Distribution of Computer-Plotted Maps,** *Stiff* Seven maps covering Kane County were placed in the Open File Series: *Aquifers with Potential for Development of Public Water Supplies*, *Bedrock Topography of Kane County*, *Drift Thickness of Kane County*, *Earth Materials of Kane County*, *Soil Drainage Characteristics of Kane County*, *Distribution and Thickness of the Tiskilwa Till in Kane County*, and *Stack-Unit Map of Kane County (to a Depth of 50 Feet)*. These color maps are produced on demand as orders are received; duplication is by means of the ISGS electrostatic plotter.

**Digital Cartographic Support Services,** *Stiff, Pool, Krumm, L. Smith* This support service of the GMDC Section included provision of a map format for plotting the Paducah Quadrangle stack map, assistance on the Kane County maps now in open file, formats for coal maps, several coverages of the Balto-Scandinavian area for slides, and extensive support of cartographic products from the CUSMAP program. Maps were produced for the Governor's transition document, Illinois State Police, and analysis of geologic mapping needs in Illinois. Poster materials and slides were produced for several conferences.

## DATABASE ENHANCEMENT

**Well Database Management System,** *Yeko and Lecouris* The development of the CONQuEST well database management system continued with the development of a graphical selection enhancement to the ToPAZ retrieval system. This selection code was completed with graphical drivers for the PC version and the Geoquest workstation version. Preliminary versions of the ISGS Monthly Drilling Report table generation programs and the data entry programs were also added to the CONQuEST programs.

Installation of SQL*Net was completed on both VAX systems, and the CONQuEST retrieval systems were modified to allow network access to the database. PC installation of SQL*Net was also completed and modification of software has begun to allow PC network access.

**NRIF Well Data Sales,** *Lecouris* Sales of computerized well data continued under the Natural Resources Information Fund agreement. Several individualized, formatting programs were written to accommodate each sale.

**Groundwater Database Activities**, *E. Smith and staff* ISGS staff continued to develop an automated groundwater database; they are using water well records and other subsurface information on file at the ISGS to develop a database of subsurface information that will be more accessible to ISGS staff and others who require this information via a computer network. The format of the database was developed by staff of the Groundwater Sections together with the Geologic Records Unit (GRU) and the Well Database Unit. Technical assistance is provided to GRU staff in the reconciliation of problems found within the water well records and permits. Assistance is also provided in the acquisition of water well information from county agencies that have primacy over water well permitting.

**Key Stratigraphic Control,** *Kempton, Follmer, Hong, others* An ongoing program to develop key stratigraphic control ensures adequate cataloging, archiving, and evaluation of all surface and subsurface data collected on Quaternary deposits. During this period, the Superconducting Super Collider wrap-up study from which the program originated was released as an open file report and progress was made in adopting elements of a proposed Quaternary data system into the Key Stratigraphic Control System.

**Data Entry of Well Information,** *Junkins, Denhart, Abert, McLean, Riggs* In connection with the County Assistance for Landfill Siting Program, temporary staff were hired to assist in the entry of well data, including water well driller descriptions, for Will, McLean, Adams, and Carroll Counties. As a result, more than 8,000 additional wells have been entered, are ready for quality-control processing, and will be added to the existing ISGS well database.

# Technical and Administrative Services

A



B



(A) Marguerite Rawdin (left) and Margret Chambers of Business and Financial Services check the account status on an invoice. (B) Workers Install exhaust stacks for new chemical fume hoods at the Natural Resources Building. Fans and motors were also relocated to the attic as part of the lab safety upgrade program. (C) New chemical fume hood. (D) Jon Goodwin, Assistant Chief, and Kathy Young, Contracts and Grants Office, examine requests for funding. (E) Tim Young, Technical Design Unit, builds a shield to keep drafts off of a sensitive microbalance. (F) Technical editors Anne Latimer and Bob Wathen discuss the layout of an Environmental Geology publication.

D



E



C



F



## TECHNICAL AND ADMINISTRATIVE SERVICES

Vital operating functions support ISGS research and service programs: budgeting, accounting, and financial reporting; contract and grant preparation and monitoring; timekeeping, counseling, and advising human resources; cataloging, searching, and locating library references; receiving and distributing incoming mail, commodities, and equipment as well as processing orders and shipping publications, maps, and other materials; maintaining the information office and the Illinois affiliate office of the National Earth Science Information Center; conducting public field trips, dealing with a variety of inquiries, and distributing educational materials; overseeing media and legislative relations; fabricating, maintaining, and repairing scientific, office, automotive, and other equipment and instruments; arranging changes in telephone programming and billing; providing editorial, graphic, typographic, duplicating, and other publication services; and planning and supervising new construction and building renovations.

The Geological Records Unit and the Geological Samples Library also provide vital technical support to research and service at the ISGS and to the public and private sectors. The documentation of Illinois geology maintained by these two units and the Reference and Map Library is the heart of ISGS activities and a basic source of information for private industry, government agencies, and the general public.

### TECHNICAL AND ADMINISTRATIVE SERVICES BRANCH OFFICE

Branch Office staff provided secretarial services for the Technical and Administrative Services Branch, recordkeeping for the Contracts and Grants Office, and telephone system/credit card changes and billing for all ISGS staff. They served as the interface between the ISGS Administrative Branch and various departments of the University of Illinois, for example, by handling requests for maintenance performed by the University Physical Plant and making reservations for University vehicles. They also handled outside requests for loan copies of out-of-print ISGS publications. Because of the severe budget crunch, the Branch Office provided half-time assistance to the Human Resource Office. Also, secretarial support was provided by typing letters, travel vouchers, various forms and reports, and field trip road logs for the Educational Extension Unit.

Responsibility for telecommunications (telephone credit cards, telephone moves/changes, phone numbers on contract, and jacks hooked into the Ethernet system) rests with this Branch Office. In addition to routine reporting of troubles with telephones, staff members handled changes in the telecommunications and billing for each personnel change or move within the Natural Resources Building and ISGS leased offices.

Draft copies of press releases, reports, contributions to outside journals and newsletters, fact sheets, correspondence, updates to the Calendar of Events, and special meeting literature prepared by the Public Liaison Officer were finalized for printing or release by this Branch Office staff. During peak production periods, both staff members assisted with this work.

Whatever the problem—burned-out light bulb, broken door lock or adjuster, malfunctioning elevator or radiator—the Technical and Administrative Branch Office prepared requests for maintenance and service from the University's Physical Plant. This staff also updated the telephone list and hall staff directories.

### BUSINESS AND FINANCIAL SERVICES UNIT

During this report period, the Business and Financial Services Unit (BFSU) focused on training and development of staff. The BFSU added two new staff members in April 1990, accepted a resignation (State Accountant) in October 1990, and granted an internal promotion (Property Control Technician) in November 1990. These personnel changes necessitated location of suitable replacements and extensive training of new and promoted staff members.

In this particularly difficult budget year, the BFSU prepared many budgetary and reduction scenarios, designed a workable reduction plan, and assisted the Management Committee members in the selection of necessary cuts to meet the FY91 reserves and FY92 funding reductions.

Through the year, the unit fulfilled its fundamental responsibilities of budgeting, purchasing, vouchering, and accounting for all funds appropriated and allocated by the State to the ISGS, as well as purchasing, vouchering, accounting, and providing budgetary support for all sponsored research funds of the ISGS.

In its continued effort to further improve efficiency, the BFSU went online with the Group Insurance System and automated reporting to the State Universities Retirement System; modified its data entry procedures on the Generalized Accounting System II (GASII) to reduce the number of keystrokes; implemented cash position reporting on indirect cost and support services accounts; and aided the Public Information Unit in designing the General Ledger accounting structure for the Great Plains point-of-sale and accounting software to be utilized in the sale of data and information.

The BFSU designed and implemented a travel-reporting system. Its purpose was to provide improved management tools for monitoring travel and for programmatic planning and evaluation.

The BFSU continued to operationalize the system for recovery of reasonable and allocable direct expenditures associated with general services rendered in support of sponsored research activities. This system has provided support for the additional services required by the large proportion of state-funded contracts and grants at the ISGS. The program has also allowed the addition of selected critical support staff in other areas of the ISGS.

The BFSU participated on the Inventory Control Committee designed to standardize the inventory procedures of the Illinois Department of Energy and Natural Resources (ENR) and assist in the formulation of an inventory policy for all divisions of ENR. These changes are expected to continue to improve the efficiency of the BFSU.

The BFSU was successful in participating in two internal Fiscal Control and Internal Auditing Act audits and one external biennial audit without material findings.

## GRANTS AND CONTRACTS

The Grants and Contracts Office (GCO) staff assisted the research staff by identifying new funding opportunities and offering guidance in all phases of proposal development. By reviewing proposal budgets and other documents, the GCO helped ensure that proposed research and service projects comply with both internal ISGS requirements and with the policies, guidelines, and regulations of the sponsoring organization, the University of Illinois, and the Board of Natural Resources and Conservation.

Summary data on the status of pending proposals and active contracts were compiled and reported to the Director of ENR, the Chief, and others on a monthly basis. Supplementary data compilations and special reports concerning grant and contract policy issues and other matters were also prepared upon the request of the Chief or the Branch Chief.

As the primary contact with the University's contract administration, the GCO helped maintain liaison with the University and routed inquiries about financial or programmatic matters to the appropriate ISGS administrative unit or staff member. When special inquiries covering multiple projects were received, the GCO coordinated compilation of information to avoid unnecessary duplication of effort and ensure the accuracy and appropriateness of the ISGS response.

A Lantastic® network was installed in the Grants and Contracts Office to ensure access to consistent and reliable information. The system allows all databases to be centralized on a single PC that can be accessed by the GCO staff, providing assurance that current and complete data are always available.

A staff member assigned to the Contracts and Grants Office provided programming, software installation, and other support for personal computers in the GCO and throughout the Technical and Administrative Services Branch. The major project for the year was the installation of a PC-based inventory control network for the Information Office and mail room to track inventory, customer invoices, and accounts receivable for sales of all publications and maps.

## HUMAN RESOURCE OFFICE

During the fall of 1990, the Human Resource Office (HRO) implemented new hiring procedures. Training was held in Springfield on the use of new interview procedures and forms. The Human Resource Officer was certified as an official interviewer. In March 1991, the Human Resource Assistant implemented a new electronic time-keeping program. Time records are now processed from the HRO computer database, and monthly reports of leave balances are generated and distributed to staff.

Of the 85 searches made during FY91, 71 were conducted on behalf of contracts and grants, and 14 were for state-funded vacancies, of which three were for hourly temporaries. Twenty-one advertisements were placed; 19 were in newspapers, and two were in professional journals. Position announcements were also posted at the University of Illinois and other major universities. The HRO received 1,410 of the 1,560 applications sent out. All applications received were acknowledged by letter.

The Human Resource Office processed the paperwork for 72 new staff members (eight state and 64 contract) and 43 resignations/terminations (seven state and 36 contract). Two staff members retired during this report period. The HRO also processed changes in benefits: 97 insurance, 33 tax cards, 32 deferred compensation applications/changes, 396 identification cards, and 88 status of participation reports to the State Universities Retirement System.

The technical assistant from the Branch Office was assigned part-time to the Human Resource Office in June 1990, primarily to assist in coordinating searches.

## LIBRARY/MAP ROOM AND PUBLIC INFORMATION UNIT

The Great Plains Accounting System, chosen to provide a networked sales and inventory computer system for the Public Information part of the unit, was installed by the Branch computer specialist. The specialist also set up the network, put five workstations online, designed the invoices, and provided system support. Unit staff were trained on the overall aspects of the Great Plains System and on customer maintenance and inventory modules. Data entry into the Great Plains System was accomplished with 700 customer records (all approved credit customers) and 5,500 inventory records (75 percent of the inventory) entered. This required entering 18,000 screens of information.

### Information Office

As the center for public inquiries, the Information Office handled general questions about the ISGS. More detailed questions were referred to appropriate scientists. The staff also handled over-the-counter sales and processed orders for ISGS maps and publications and USGS maps of Illinois. This office was also responsible for bookkeeping of sales, maintenance of gift and announcement mailing lists, response to gift and exchange claims, and cooperating with the Publications Unit to determine print runs based on anticipated sales and gift and exchange distribution.

Selected mailing lists were entered into the InMagic Database Management System. By having these mailing lists on InMagic, we are now able to quickly determine which lists an individual is on and how many names are on each list; we can also sort by several fields. A third major project completed was the List of Publications Update for 1990. The Information Office was physically reorganized to improve the customer service area and increase the space for computers.

### Mail Room

The central receiving and distribution center for the ISGS is the Mail Room. Its staff handled shipments, received and sorted mail, processed bulk mailings, and ordered and stocked office supplies. Outgoing orders were also filled and shipped. Stocks of all in-print materials were maintained to fill outside orders and distribute to the staff.

**Mail Room Operating Statistics**

| | *FY90* | *FY91* |
|---|---|---|
| ISGS publications distributed | 21,997 | 24,517 |
| ISGS maps distributed | 2,484 | 3,224 |
| ISGS blueline maps distributed | 3,218 | 2,990 |
| USGS maps distributed | 27,833 | 21,625 |
| Orders filled | 5,498 | 7,320 |
| Number of pieces mailed | 46,663 | 60,934 |
| Mailing costs | $21,665.00 | $26,210.00 |
| Average mailing cost per piece | $0.46 | $0.43 |

Storage shelves for newly published maps and office materials, and a secure area to hold incoming shipments were built for the Mail Room by the Technical Design Unit. Two reorganizations of the Mail Room also took place: topographic map inventory was reorganized to provide office space for the Branch computer specialist who assisted with the Great Plains System; and the publications inventory was reorganized to provide space for ISGS staff mail boxes. An inventory of attic materials was completed.

Individual orders filled in FY91 totaled 7,320, an increase of 1,822 orders over last year's total of 5,498 (see table above). This increase is attributed to the distribution of the List of Publications Update and the increased number of announcements mailed. There was a significant increase in number of pieces mailed, which led to the increase in total mailing costs; however, the average cost per item mailed decreased. The increase in number of pieces mailed is the result of distributing the first ISGS calendar last December and increasing the mailing of announcements.

**Library/Map Room**

The Library/Map Room provides reference services mainly to ISGS staff. Journals, acquisitions lists, and other materials are routed to alert staff to new publications and developments in their fields. Citations are completed and verified, bibliographies prepared, online literature searches run, and articles, books, and reports located and borrowed. Instruction in the use of the University of Illinois libraries, the Illinet Online computer system, and our own library is available upon request. We also fill interlibrary loan requests received through the Lincoln Trail Libraries System and other libraries.

| Library Operating Statistics | 1988-89 | 1989-90 | 1990-91 |
|---|---|---|---|
| *Acquisitions—total* | *2,045* | *2,021* | *1,388* |
| Books | 80 | 130 | 123 |
| State documents | 496 | 405 | 533 |
| U.S. documents | 573 | 337 | 346 |
| Canadian documents | 64 | 57 | 46 |
| Miscellaneous documents | 227 | 125 | 175 |
| Manuscripts | 50 | 21 | 42 |
| Maps | 547 | 852 | 123 |
| Photos, slides, and miscellaneous | 8 | 94 | 8 |
| *Items withdrawn—total* | *108* | *82* | *2,531* |
| Serials titles and newsletters received | 313 | 315 | 299 |
| *Library circulation—total* | *3,185* | *2,734* | *2,772* |
| Books, documents, serials, miscellaneous | 1,929 | 1,829 | 1,899 |
| Maps | 991 | 590 | 608 |
| Field notebooks, photos, slides, miscellaneous | 87 | 208 | 73 |
| Interlibrary loans (lent) | 178 | 107 | 192 |
| *Journal routing* | | | |
| Periodicals routed | 1,769 | 1,662 | 1,614 |
| Tables of contents routed | 462 | 422 | 484 |
| *Interlibrary loans (borrowed)—total* | *778* | *766* | *768* |
| • from UI libraries | 200 | 330 | 360 |
| • through Lincoln Trail Libraries System | 318 | 292 | 213 |
| • direct from other libraries | 260 | 144 | 195 |
| Reference questions | 1,504 | 1,945 | 1,904 |
| Online bibliographic searches | 42 | 63 | 49 |
| Visitors (non-staff) | 278 | 272 | 181 |
| Outside phone requests | 158 | 201 | 258 |

Because of seriously limited space, an aggressive weeding program was pursued this past year and it will continue. Collections of Canadian and state documents were weeded, and the sections shifted to make room for new materials. Journals no longer received and rarely used were identified with the help of the Library Committee; they will be weeded this coming year.

Reference requests remain high, especially requests for verifying difficult citations and obtaining the materials. The CDROM version of the GeoRef database was installed on a trial basis for 1 month. It generated 75 percent of our annual online bibliographic search activity. This implies that a considerable demand for such services is not being met by the current pay-per-search system available now.

### Earth Science Information Center (ESIC)

This office provided geodetic and general cartographic information in response to 563 requests from the public. It also maintained the inventory of U.S. Geological Survey (USGS) topographic maps. New or revised editions of 170 maps in the 7.5-minute (1:24,000-scale) quadrangle series are in preparation in five separate projects. The USGS is funding the largest projects: 72 maps in northeastern Illinois, 33 maps in the quad cities area, and 32 maps in southwestern Illinois. A 26-map project in southern Illinois is funded by the U.S. Forest Service. A smaller project involving seven maps in the Rockford area is jointly funded by Illinois and the USGS. There is now a published map for each of the 47 quadrangles in the 1:100,000-scale (30×60-minute) series. Thirty-five quadrangles are covered by both planimetric and topographic editions. Nine quadrangles have topographic coverage only, and three have only planimetric coverage. Completion of topographic coverage in this series is expected in late 1992. In the 1:100,000-scale county map series, 58 maps have been published; 56 have been received by the ISGS.

### Duplicating Services

Most ISGS materials, except for 4-color and oversized items, can be reproduced by the Duplicating Shop. Binding by the Bourg Perfect Binder has been popular and is being used for nearly all ISGS publications. An improved vacuum system for the binder, developed by the Technical Design staff, has made long binding runs possible. The workload has been consistently heavy, often requiring additional help from unit staff and/or students. This past year the duplicating shop produced 2,841,359 impressions.

## PUBLIC LIAISON

Besides informing the public and decision makers about ISGS research and service programs and projects, Public Liaison has added responsibilities for governmental relations and selected strategic planning activities. During the last reporting period, a concerted effort was launched by this staff of one to apprise governmental officials at all levels—local, county, regional, state and federal—of ISGS work as it relates to strengthening the state's economy and improving the quality of life of Illinois' citizens.

Funding constraints on all sectors and the urgency to make prudent and safer use of the land available for resource and economic development reinforce the need for this form of information and technology transfer to governmental units. More regional planning, involving wise, environmentally sound decisions about siting new facilities or locating, developing and protecting natural resources, places the ISGS, with its vast geological knowledge and expertise as well as its databases, in a position to assist in vital decision-making processes. To this end, the Public Liaison Officer is reaching out to grassroots officials and community leaders; city, county and regional planners, engineers and zoning officers; legislators and their staff; and departments of state government to inform them about ISGS earth science research and service that responds to the multitude of complex environmental- and resource-related issues facing the state. During this fiscal year, personal visits were made to members of these audiences and the news media in central, southeast central and southern Illinois, delivering packets of information about and discussing major projects and service programs.

Prompting a better understanding of the ISGS and its work and promoting closer relations between the ISGS and the Illinois delegation in Washington, D.C., the Illinois General Assembly, the Department of Energy and Natural Resources, other governmental agencies, the Nature of Illinois Foundation, news media, target groups and the public, this unit has provided a flow of in-depth information. News of research and service has been disseminated through a mini-annual report written especially for the public for the third consecutive year; meetings for special interest groups; articles for magazines, newsletters and journals; personal letters and visits; press releases and editorial commentary; fact sheets; reports; brochures; and exhibits.

Relying on a display of pictures, maps and graphics, the unit has presented ISGS work on behalf of Illinois' resources, environment, and economic development and related issues confronting the state. This 10-foot exhibit has been taken to the DuQuoin State Fair, fall and spring county officials' meetings, a quarterly meeting of the Board of Natural Resources and Conservation, the Nature of Illinois Foundation's meeting with community and industrial leaders and the media in Chicago, Earth Day Weekend, and the annual meetings of the Geological Society of America, Illinois Science Teachers and the Illinois Aggregate Producers. A similar display was designed and used by the American Association of State Geologists (AASG) to explain, in general terms and pictures, what the overall program of State Geological Surveys covers. The AASG display was erected and hosted by the Public Liaison at the annual meetings of the Geological Society of America and the American Association of Petroleum Geologists during this reporting period.

In addition, the Public Liaison prepared articles for The Nature of Illinois Foundation's magazine; the American Association of State Geologists' newsletter; ENR's "Illinois Resources"; "Illinois Energy" newsletter; and ENR's annual report. Besides teaming media with scientists working on specific issues, the unit arranged interviews for both the print and electronic media.

Working with ISGS scientists, the unit prepared press releases on personnel changes, awards or special recognition, funding for specific programs, geological science field trips, groundwater protection, study of pesticides in rural wells, study on the proximity of underground mines to residential and other built-up areas, the use of old electric logs in the analysis of sandstone reservoirs, assistance to counties for resource assessment, the submerged forest in Lake Michigan, and an earthquake fact sheet focusing on Illinois. While the Public Liaison Officer generated press releases and advertisements to market new publications, their distribution was enhanced by the creation of new or the updating of selected mailing lists containing more than 3,000 addresses.

## PUBLICATIONS, GRAPHICS, AND PHOTOGRAPHY

A *Special Achievement Award* was given to the Publications, Graphics, and Photography Unit in recognition of its contributions to the Illinois State Geological Survey during 1989-90. During 1990-91, publication output compared well with the previous year's production (tables 1 and 2).

The Publications team lost a fine editor when Mary Glockner retired at the end of February 1991. Ms. Glockner's experience and expertise cannot be easily replaced.

Major format graphics were in high demand (table 1). ISGS graphics staff handle the entire production chain, from rough work copy furnished by scientists through the multiple positives ready for the presses or a polished composite for diazo reproduction. Final products included three cross sections of the Illinois Basin, four plates of stratigraphic columns and cross sections to accompany CUSMAP's bedrock geology map, two cross sections of the proposed low-level radioactive waste disposal site at Geff in Wayne County, numerous cross sections for the Groundwater Resource Section's commitment to IDMM, major contributions to Illinois Geologic Quadrangles 4-6, and a major plate for Bulletin 96.

**Innovation, renovation** Bulletin 96, *Geology of the Eddyville, Stonefort, and Creal Springs Quadrangles, Southern Illinois*, the first Bulletin to be published since 1975, came out in 1991. The new format, created by the graphics staff, is both attractive and cost effective—designed to be reproducible in the ISGS Duplicating Shop.

In the spring, work began on the photography lab—remodeling the dark room and creating a new editorial office. Increased efficiency in production of prints and negatives will be an important benefit to the Unit. Also, the ISGS and INHS photographers collaborated on a special project. They acquired lighting (three studio strobes) and a multiple-screen backdrop (9 ft long by 8 ft high) from the Office of Instructional Media at the University of Illinois, then offered a new service—portrait and studio photography.

**ISGS publications** for July 1, 1990, through June 30, 1991:

**Bulletin series** comprehensive scientific reports and reference works of lasting significance.

B 96 *Geology of the Eddyville, Stonefort, and Creal Springs Quadrangles, Southern Illinois.* 1991. W. J. Nelson, J. A. Devera, R. J. Jacobson, D. K. Lumm, R. A. Peppers, B. Trask, C. P. Weibel, L. R. Follmer, M. H. Riggs, S. P. Esling (SIU), E. D. Henderson (SIU), and M. S. Lannon (SIU). 1991. 85 pages, 7 tables, 58 figures, 2 plates.

**Table 1. Final Projects***

| | *1987-88* | *1988-89* | *1989-90* | *1990-91* |
|---|---|---|---|---|
| Bulletins | 0 | 0 | 0 | 1 |
| Circulars | 3 | 2 | 1 | 2 |
| Environmental Geology series | 9 | 3 | 3 | 6 |
| Cooperative Groundwater Reports | 0 | 2 | 1 | 0 |
| Illinois Mineral series | 3 | 2 | 2 | 3 |
| Illinois Petroleum series | 3 | 2 | 1 | 2 |
| Illinois Mine Subsidence Research (limited series) | 5 | 1 | 0 | 0 |
| Illinois Basin Consortium (new series) | - | - | 1 | 0 |
| Educational Extension Field Trip Guides | 6 | 4 | 4 | 4 |
| Reprints of outside publications | 22 | 18 | 17 | 19 |
| Contract/Grant Reports (discontinued series) | 1 | 2 | 5 | - |
| Open File Series | - | - | - | 7 |
| Illinois Scientific Surveys Joint Reports | 0 | 0 | 2 | 0 |
| Papers, book chapters, miscellaneous text (>5 p) | 36 | 22 | 15 | 21 |
| Major-format maps, cross sections, strat columns** | 3 | 3 | 0 | 12 |
| Posters, displays, major slide programs | 46 | 24 | 25 | 20 |
| Brochures, fliers, announcements of pubs | 19 | 15 | 14 | 18 |
| Administrative and miscellaneous reports | 20 | 9 | 3 | 3 |
| Geonews | 3 | 3 | 2 | 2 |

* tally of projects only (published or unpublished), with no accounting for size and complexity.
** includes plate from B96; but excludes 22 cross sections for IDMM and Illinois Geologic Quadrangles.

**Circular series** reports of significant discoveries or advances in general geology or related research, stratigraphy, or topical areas not covered in the other series.

C 545 *Study of Sulfur Behavior and Removal During Thermal Desulfurization of Illinois Coals.* 1990. K. C. Hackley, R. R. Frost, C.-L. Liu, S. J. Hawk, and D. D. Coleman. 33 pages, 22 tables, 24 figures.

C 547 *Facies Analysis of the Ordovician Maquoketa Group and Adjacent Strata in Kane County, Northeastern Illinois.* 1991. A. M. Graese. 36 pages, 1 table, 23 figures.

**Environmental Geology series** reports of significant discoveries or advances in basic and applied environmental geological research.

EG 134 *Numerical Estimates of Potential for Groundwater Contamination from Land Burial of Municipal Wastes in Illinois.* 1990. B. R. Hensel, R. C. Berg, and R. A. Griffin. 84 pages, 24 tables, 26 figures.

EG 135 Jointly published with HWRIC as EG 135/HWRIC RR051: *Investigation of the Hydraulic Effects of Deep-Well Injection of Industrial Wastes.* 1990. E. Mehnert, C. R. Gendron, and R. D. Brower. 100 pages, 26 tables, 80 figures.

EG 136 *Seismic Reflection and Seismic Refraction Surveying in Illinois.* 1990. P. C. Heigold. 52 pages, 1 table, 18 figures.

EG 137 *Geochemical Interactions of Two Deep-Well Injected Wastes with Geological Formations: Long-Term Laboratory Studies.* 1990. W. R. Roy, B. Seyler, J. D. Steele, D. M. Moore, I. G. Krapac. 17 pages, 4 tables, 3 figures.

EG 138 *The Proximity of Underground Mines to Residential and Other Built-up Areas in Illinois.* 1991. C. G. Treworgy and C. A. Hindman. 18 pages, 9 tables, 5 figures.

EG 139 *Geotechnical Properties of Selected Pleistocene, Silurian, and Ordovician Deposits of Northeastern Illinois.* 1991. R. A. Bauer, B. B. Curry, A. M. Graese, R. C. Vaiden, W. J. Su, and M. J. Hasek. 92 pages, 27 tables, 25 figures, 15 apps.

**Table 2. Graphics***

| | *1988-89* | *1989-90* | *1990-91* |
|---|---|---|---|
| Assorted maps, cross sections, graphs, layouts | 951 | 556 | 591 |
| Graphics for ISGS publications* | 500 | 537 | 466 |
| Graphics for *Basins* volume and poster | - | 650 | - |
| Major format items (60 to 150 hrs each) | - | - | 12 |
| ***Typographics*** *(number of typeset pages of text, slides, tables, forms)* | | | |
| Linotype typography | 2,700 | 2,600 | 1,485 |
| Computer typography | - | - | 552 |
| ***Photographics*** | | | |
| Photos taken for staff | 6,336 | 4,800 | 5,200 |
| 2 x 2 inch slides: color | 2,600 | 3,100 | 2,950 |
| duplicates | 3,200 | 2,900 | 3,000 |
| Internegatives | 300 | 480 | 450 |
| Negatives, total | 179 | 300 | 250 |
| fineline | 65 | 120 | 25 |
| high-contrast | 85 | 150 | 200 |
| screened | 29 | 30 | 25 |
| PMT prints developed for staff, total | 4,835 | 5,430 | 5,800 |
| screened | 270 | 210 | 320 |
| reversal and acetate | 165 | 120 | 140 |
| line (not split out before) | 4,400 | 5,100 | 5,340 |
| Prints made, total | 5,450 | 5,250 | 4,950 |

* artists design, create layouts, and paste up publications; this work is measured in hours, rather than numbers of illustrations.

**Illinois Minerals series** reports of significant advances in basic and applied research in the area of mineral resources or economics.

IMN 104 *Industrial Minerals and Metals Publications of the Illinois State Geological Survey through December 1989.* 1990. J. H. Goodwin, D. G. Mikulic, and J. W. Baxter. 33 pages.

IMN 105 *Illinois Mineral Industry in 1988 and Review of Preliminary Mineral Production Data for 1989.* 1990. I. E. Samson and S. B. Bhagwat. 43 pages, 25 tables, 13 figures.

IMN 106 *Cross Section of the Paleozoic Rocks of Northeastern Illinois: Implications for Subsurface Aggregate Mining.* 1990. D. G. Mikulic. 14 pages, 7 figures.

**Illinois Petroleum series** reports of significant discoveries or advances in basic or applied research in the area of oil and gas resources.

IP 134 *Application of Old Electric Logs in the Analysis of Aux Vases Sandstone (Mississippian) Reservoirs in Illinois.* 1990. H. E. Leetaru. 21 pages, 19 figures.

IP 136 *Hydrocarbon Source Potential and Organic Geochemical Nature of Source Rocks and Crude Oils in the Illinois Basin.* 1991. M.-I.M. Chou, D. R. Dickerson, S.-F.J. Chou, and M. L. Sargent. 39 pages, 11 tables, 14 figures, 5 apps.

**Educational Extension Geological Field Trip booklets**

1990-C *Oregon Area, Ogle County.* September 1990. D. L. Reinertsen.

1990-D *Nashville Area, Washington County.* October 1990. D. L. Reinertsen, S. T. Whitaker, P. C. Reed, and L. R. Follmer.

1991-A *Fairfield Area, Wayne County.* April 1991. C. P. Weibel and D. L. Reinertsen.

1991-B *Kewanee Area, Henry and Bureau Counties.* May 1991. D. L. Reinertsen.

**Guidebook series** discussions of geology, stratigraphy, structure, and other natural features that are the focus of major field trips.

G 21 *Wisconsinan and Sangamonian Type Sections of Central Illinois.* 1990. E. D. McKay. 48 pages (AMQUA guidebook reissued as an ISGS Guidebook).

G 22 *Quaternary Records of Northeastern Illinois and Northwestern Indiana.* 1991. A. K. Hansel and W. H. Johnson. 106 pages. (AMQUA guidebook reissued as an ISGS Guidebook)

**Open File Series**

OFS 1990-3 *3 O'Clock Cross Section in the Illinois Basin: Wayne County, Illinois, to Switzerland County, Indiana.* 1990. J. D. Treworgy and S. T. Whitaker. Vertical scale 1 in. = 400 ft; horizontal scale 1:250,000.

OFS 1990-4 *9 O'Clock Cross Section in the Illinois Basin: St. Clair County to Wayne County, Illinois.* 1990. S. T. Whitaker and J. D. Treworgy. Vertical scale 1 in. = 400 ft; horizontal scale 1:250,000.

OFS 1990-5 *1 O'Clock Cross Section in the Illinois Basin: Wayne County, Illinois, to Lake County, Indiana.* 1990. J. D. Treworgy and S. T. Whitaker. Vertical scale 1 in. = 400 ft; horizontal scale 1:250,000.

OFS 1990-8 *The Superconducting Super Collider Collection: Bibliography and Archival Listing of Materials at the Illinois State Geological Survey.* 1990. P. G. Wasson. 98 pages.

OFS 1991-1 *Quaternary Geology of the Martinsville Alternative Site, Clark County, Illinois.* 1991. B. B. Curry, R. C. Berg, and M.R.T. Cartwright. 148 pages, 4 tables, 29 figures, 1 app.

OFS 1991-2 *Quaternary Lithostratigraphy of the Martinsville Area North to the Martinsville Alternative Site.* 1991. B. B. Curry, R. C. Berg, and M.R.T. Cartwright. 68 pages, 2 tables, 23 figures, 1 app.

OFS 1991-10 *Correlation of Upper Pennsylvanian Bedrock Strata at the Proposed Low-Level Radioactive Waste Disposal Facility at the Geff Alternative Site, Wayne County, Illinois.* 1991. C. P. Weibel. 2 cross sections.

**Illinois Geologic Quadrangles (IGQ) and Other ISGS Maps, Cross Sections, Stratigraphic Columns**

IGQ 4 *Geologic Map of the Creal Springs Quadrangle, Illinois.* 1990. C. B. Trask and R. J. Jacobson. Full color, scale 1:24,000.

IGQ 5 *Geologic Map of the Eddyville Quadrangle, Illinois.* 1990. W. J. Nelson and D. K. Lumm. Full color, scale 1:24,000.

IGQ 6 *Geologic Map of the Stonefort Quadrangle, Illinois.* 1990. W. J. Nelson and D. K. Lumm. Full color, scale 1:24,000.

ISGS Map Series *Potential for Aquifer Recharge in Illinois (Appropriate Recharge Areas).* 1990. D. A. Keefer and R. C. Berg. Full color, scale 1:1,000,000.

22 IDMM Cross Sections *Geologic Framework for Determining Underground Sources of Drinking Water*, 1990, D. J. Berggren, R. D. Brower, C. A. Chenoweth, A. M. Graese, V. L. Poole, Reed, E. C. Smith, T. Shaw, J. D. Treworgy, R. C. Vaiden, C. P. Weibel: *from* set of 150 cross sections (identified by county), *prepared for* Illinois Department of Mines and Minerals.

CUSMAP *Bedrock Geology of the 1° × 2° Paducah Quadrangle* (geologic columns and cross sections). W. J. Nelson. Four 40 × 32 inch sheets.

**Reprints of papers published in journals or proceedings**

1990 1990E, *Coal: World Resources*, H. H. Damberger • 1990F, *Coal: Geology*, R. D. Harvey • 1990G, *Abundance and Origin of Major Minerals in the Herrin Coal, Illinois Basin*, I. Demir and R. D. Harvey • 1990H, *Abundances and Leachabilities of Sodium and Chlorine in Lithotypes of Illinois Basin Coals*, I. Demir, C.-L. Chou, and C. Chaven • 1990J, *Late Wisconsinan and Holocene Littoral Drift Patterns in Southern Lake Michigan*, M. J. Chrzastowski • 1990K, *Estimate of the Natural-State Littoral Transport Along the Chicago Lakeshore*, M. J. Chrzastowski • 1990L, *1989 Shore Erosion and Rapid Developments of Logarithmic-Spiral Recession at North Point Marina, Lake County, Illinois*, M. J. Chrzastowski and P. D. Terpstra • 1990M, *Geochemistry of Sulfur in Coal*, C.-L. Chou • 1990N, *Fluvial-Estuarine Valley Fill at the Missippian-Pennsylvanian Unconformity, Main Consolidated Field, Illinois*, R. H. Howard and S. T. Whitaker.

1991 1991A, *Evidence for Post-Two Creeks Age of the Type Calumet Shoreline of Glacial Lake Chicago*, A. F. Schneider and A. K. Hansel • 1991B, *Construction and Performance of a Long-Term Earthen Liner Experiment*, K. Cartwright and I. G. Krapac • 1991C, *Impact of Riverine Wetlands Construction and Operation on Stream Channel Stability: Conceptual Framework for Geomorphic Assessment*, B. L. Rhoads and M. V. Miller • 1991D, *Numerical Assessment of a Landfill Compliance Limit*, B. R. Hensel, D. A. Keefer, R. A. Griffin, and R. C. Berg • 1991E, *Memorial to Walter Henry Voskuil, 1892-1984*, J. A. Simon • 1991F, *Memorial to Hubert Elias Risser, 1914-1974*, J. A. Simon • 1991G, *Memorial to Harold Bowen Willman, 1901-1984*, J. A. Simon and E. Atherton • 1991H, *Evidence for the Intra-Glenwood (Mackinaw) Low-Water Phase of Glacial Lake Chicago*, G. W. Monaghan and A. K. Hansel • 1991I, *The Building, Deterioration, and Proposed Rebuilding of the Chicago Lakefront*, M. J. Chrzastwoski • 1991J, *Leaching Behavior of Fine-Coal Cleaning Waste Solids*, G. B. Dreher, W. R. Roy, and J. D. Steele.

**Special Publications**

Legislative report — *Geologic Mapping for the Future of Illinois*. 1991. M. W. Leighton, H. H. Damberger, and others. 55 pages, 50 figures.

Papers, misc text (>5 p) — *for* McKenna, Hensel, Eidel, Larson/Cartwright, Frost (2), Nelson (4), Herzog, Dreher (2), Leighton, Weibel, Heigold/Kolata, Roy (2), Hughes/Moore, Kolata, Stohr.

Catalog — *1990 Additions to the Geological Samples Library*. 1991. C. J. Zelinsky.

Posters, major slide programs — *for* C.-L. Chou, Hackley, Goodwin, Muckensturm (2), Wolf, Reed/Brower, Herzog, Killey, Cole, Moore, Kolata, Stohr, Leighton (2), Nelson, Whitaker, Whitaker/Leetaru, Dexter.

*Geonews* — Summer 1990, Winter 1991.

Annuals — ISGS 1991 Calendar and two reports • *Illinois State Geological Survey Annual Report, July 1989 - June 1990*. 180 pages, 45 photos • *ISGS 1989-90, Science on Energy, Groundwater Protection*. S. Muckensturm. 32 pages, 1 figure, 21 photos.

AAPG — *Interior Cratonic Basins*. 1990. M. W. Leighton, D. K. Kolata, D. F. Oltz, and J. J. Eidel (editors). American Association of Petroleum Geologists Memoir 51. 819 pages. 350 figures.

## TECHNICAL DESIGN, OPERATIONS, AND MAINTENANCE UNIT

The Technical Design, Operations, and Maintenance Unit provides multiple services to the ISGS. A woodworking shop, metal and machine shop, electronics shop, and automotive section plus a drill rig and operator provide special services that would otherwise have to be handled through the University of Illinois or contractual services with outside vendors. ISGS shop craftsmen design and construct specialized pieces of equipment for the scientific and office staff. They provide custom drilling services and schedule and maintain the ISGS automotive and special vehicle fleet. They are also responsible for the upkeep and maintenance of the Shop and Equipment Building and the Clay Hydrogeology Liner

A



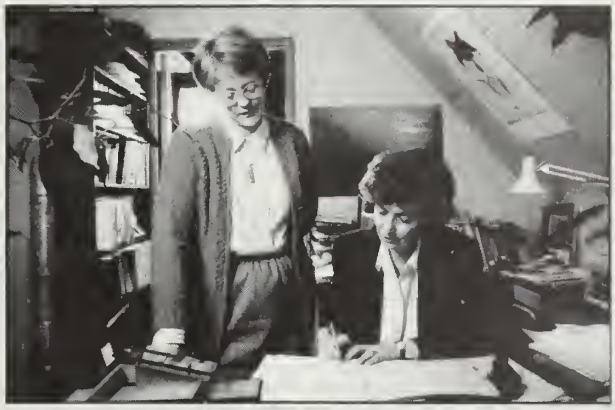
B



C



D



E



(A) Ed Scoggin, Public Information Unit, weighs an envelope for postage. (B) Mary Jones and John Klitzing check records at the Geological Samples Library. (C) Kimbra Burris of Geological Records runs a long continuous copy of wireline logs. (D) Mary Krick (standing) and Ellen Wolf coordinate schedules between the Print Shop and the Publications Unit. (E) Vicky Welser, Business and Financial Services, photocopies account statements. (F) Water Well Task Force members Jeff Taylor (from left), Rita Sutter, Kimbra Burris, Chuck Zelinsky, and Monica Rech prepare to enter water well permit records into the main geological database. (G) Craftsman Mike Dodd constructs a table for the new photographic darkroom.

F



G



Building and grounds. Extra effort is made to provide safe and efficient work areas and to install, repair, and maintain laboratory, office, and field equipment in a cost effective and timely manner.

During the report period, 431 internal work orders were completed, requiring repairs, fabrication, moving, maintenance and other services. Many other jobs were performed in response to verbal requests, notes, and regular maintenance routines.

**Highlights of Activities** Phase II of the Natural Resources Building laboratory upgrade began this year. The unit works closely with the Branch Chief in planning and coordinating this project and plays a major role in moving office and scientific equipment in and out of labs to accommodate remodeling activities. Moving the ISGS Chicago field office from the State of Illinois Center to Batavia with the accompanying task of locating additional furniture, painting of file and storage cabinets, and building dividers was another accomplishment of the unit.

### Woodworking Shop

Custom computer workstations, tables, desk organizers, bookshelves, and map cases are a specialty of the woodworking and metal shops; 30 different types were constructed during this report period. Shop personnel also restored and refinished desks, tables, chairs, and file cabinets.

### Machine and Metal-Working Shop

The machine shop routinely designs and constructs special apparatus for ISGS staff. Of special note was the design and construction of a special fixture to manufacture aluminum holders for micro-paleontological slides; the holders would have had to be specially ordered and were prohibitively expensive. Shop personnel also designed a modification to the vacuum system of the book binder in the print shop—an improvement that eliminated unproductive and expensive service calls.

### Electronics Shop

The electronics shop provides support in electrical/electronic maintenance and repair of scientific equipment and in coordination of site preparation on new equipment installations throughout the ISGS. Ethernet and other computer cabling hook-ups as well as telephone installation and repair are other shop responsibilities.

Of special value to the ISGS is the staff's ability to repair field equipment for rapid turnaround to field use and to maintain antiquated equipment for research purposes. An example is the Nuclide Mass Spectrometer used in the Isotope laboratory; it suffered lightning damage but was considered "obsolete" for repair purposes. The electronics shop staff repaired it, and it is in routine use again.

### Drill Rig

The ISGS drill rig was employed on six successful projects during this report period. Projects included installation of inclinometers and groundwater monitoring wells with piezometers, and continuous core sampling. The drill rig operator coordinates work closely with ISGS staff to effectively complete their research projects and performs routine drill rig maintenance along with other unit assignments.

A continuous sampler for the 4.25-inch auger was purchased this year and allows continuous sampling when installing monitoring wells. Repairs were made to the drill rig transmission and hydraulic valves to prevent fluid leakage, and the rig bed was repainted to prevent rusting.

### Automotive Section

Servicing and keeping records on the 25 vehicles of the ISGS and the 52 vehicles of the Illinois Natural History Survey is the responsibility of the automotive section, which also handles dispatching for ISGS vehicles. Assuring the readiness and safety of automotive and special purpose vehicles is important to the performance of business and field activities at both Surveys.

The ISGS requisitioned four new vehicles this past year. They replaced one vehicle that was totaled in a wreck and three vehicles that had been driven more than 100,000 miles. The ISGS operational cost for the fleet this year was 8.5 cents per mile. Following a strict maintenance schedule has kept our costs to a minimum.

The staff converted an existing pressure washer and added a detergent pump to facilitate washing vehicles in our present wash bay. The new service keeps expenses to a minimum and makes it less time-consuming to keep vehicles clean and rust free.

### Applied Research Laboratory Shop

The Machine, Operations, and Maintenance Shop provides the Applied Research Laboratory with special services that would otherwise have to be handled through contractual services or by the University of Illinois. The shop provides custom design, fabrication, and repairs to laboratory and scientific apparatus, office equipment, and furniture. Several jobs were noteworthy during this report period:

- designed and built new walls to subdivide rooms 212 and 204;
- designed and built new fume hood in room 203;
- designed and built new dust hood in room 105A;
- worked with University of Illinois Crafts on remodeling;
- remodeled storage bins.

## EDUCATIONAL EXTENSION

The Educational Extension Unit provides information and materials on the state's geology, mineral resources, and landscape to elementary, high school, and college teachers, students, and the general public. The staff also presents slide-illustrated talks about ISGS research and service activities to teacher workshops and citizen groups throughout the state.

### Geological Science Field Trips

Although designed to furnish teachers with background materials for classroom use, the four field trips held each year are popular events for the public as well. A guidebook is furnished to the participants. Additional guidebooks from more than 80 previous field trips are maintained on permanent file to allow teachers and others to obtain them for future reference. During the year, the ISGS hosted field trips to the Oregon area on September 29, 1990, the Nashville area on October 27, 1990, the Fairfield area on April 20, 1991, and Kewanee on May 18, 1991. Of the 492 attendees, 144 were elementary, high school, and college students, and 71 were elementary, secondary, and college teachers.

On the Oregon field trip, Dr. Leighton told about the structural evolution of North America and the effect this had on the formation of our mineral resources. On the Nashville area field trip, a geologist from the Oil and Gas Section described problems oil well operators encounter extracting oil from reservoirs and the research now under way at the ISGS to increase the amount of oil recovered from existing fields through better characterization of the geology of the reservoir rocks.

### Teacher Workshops

The unit participated in several workshops for teachers. The unit presented the slide-illustrated lecture, "Introduction to the Geology and Occurrence of Illinois' Coals," for a workshop on energy offered by Energy Education Associates in Downers Grove on July 16, 1990. A slide-illustrated lecture, "The Geology of the Chicago Area," was presented to a teacher workshop at the Chicago Academy of Science and Mathematics on February 8, 1991. The unit presented a lecture on earth science materials that are available from the ISGS for classroom use at a teacher workshop at Western Illinois University in Macomb on June 25, 1991.

### Displays

A display of fluorite and associated minerals from Illinois was exhibited along with the *Satellite Image Map of Illinois* at the annual show of the Double I Rock and Mineral Society held at the Vermilion County Historical Museum in Danville on September 8 and 9, 1990; the display remained there until November 9, 1990. The six-panel display about ISGS research activities was used at the Nature of Illinois Foundation press meeting and awards presentation in Chicago on October 30, 1990. The ISGS research activities display was also used at the annual meeting of the Illinois Science Teachers Association held at Governor's State University in Matteson from November 1 to 3, 1990. The unit helped transport and set up the biodiversity display at Belleville Area Community College for the Nature of Illinois Foundation on February 21, 1991.

### Other Activities

Color slides from the Educational Extension Unit's extensive collection have been used by several staff members from other sections for publications and talks. The head of this unit continues to attend meetings of the Statewide Advisory Board on Conservation Education of the Illinois State Board of Education and an ISGS representative on the Groundwater Protection Education Subcommittee.

## GEOLOGICAL RECORDS AND SAMPLES LIBRARY

On April 16, 1991, the administration of the Geological Records and Samples Library was transferred from the Mineral Resources and Engineering Branch to the Technical and Administrative Services Branch. The transfer was carried out to better reflect the service functions these units provide to all ISGS units, other agencies of state government, and the general public. Many activities of these units were closely tied to the public information sales and distribution functions of the Technical and Administrative Services Branch. This transfer should allow better coordination of these closely allied functions.

As a result of the continued decline in the oil and gas industry and water well drilling, the overall volume of data handled by Geological Records decreased slightly in 1990-91 (see table). The downturn of petroleum industry records was partially offset as a result of revitalized efforts of the ISGS and the Illinois Department of Mines and Minerals to obtain required records that have not been received. The number of oil and water well samples processed by the Geological Samples Library increased during 1990-91.

### Geological Records Unit

The Geological Records Unit (GRU) is the repository for drilling records in Illinois, including oil and gas wells, water wells, engineering borings, and miscellaneous test holes. This database has long been of value to the oil industry, coal industry, hydrogeolgists, engineers, land-use planners, academic institutions, landowners, the general public, and ISGS staff.

Total pieces of mail processed decreased (2,595 less than FY91) partly as a result of receiving 1,855 fewer water well permits and 3,088 fewer water well logs than the previous year. Geological Records continues to receive donations of well data from the drilling industry. During the report period, 3,421 logs were checked against existing well records and 1,369 logs were added to the records collection.

GRU staff assist visitors and ISGS scientists with requests for information regarding drill-hole records on file. Usage of the facility increased by 44 visitor days (1,029) during the report period. GRU staff received 3,581 phone requests, 236 more than the previous year. Total orders processed increased by 225 (1,837 in FY91 as compared with 1,612 the previous year). Copy service activity increased during the past year; GRU staff copied 7,216 continuous logs and 49,107 single sheets of well data (as compared to 5,475 continuous logs and 37,878 single sheets during the previous year).

**Noncompliance Project** A cooperative effort between the Oil and Gas division of the Illinois Department of Mines and Minerals (IDMM) and the ISGS Geological Records Unit began October 1, 1990, to revitalize efforts to obtain required well records. During the past reporting period, IDMM instituted a number of enforcement rules and procedural changes relative to well-site violations. These changes included issuance of Notices of Violation (NOVs) to noncompliant operators regarding well records. To assist the DMM, the ISGS has been preparing a quarterly list of those permitted wells for which required records have not been received. Since October 1, 1990, 646 noncompliant owner/operators have been contacted by IDMM requesting required records that have not been received. GRU handled 584 responses by phone or by mail. As a result of the cooperation between IDMM and ISGS, GRU has received and processed into the files more than 4,500 records of various kinds that had not previously been supplied. The response from the drilling industry to this program has been positive.

**Grandfathered Oil Well Permits** IDMM is requiring operators who had producing oil wells drilled prior to 1940 but did not have permits issued at that time, to reapply for a current permit. The IDMM estimates that there may be as many as 5,000 such wells, and they have offered to issue these new permits without charging a fee until the end of August 1991. GRU has received 437 of these "grandfathered" permits during the report period. Since location information supplied by the operators of these wells commonly does not match our available historical records, the processing of these records is usually time-consuming, causing a backlog (about 2 months) in processing new permit information. IDMM intends to contact operators who did not respond to this program and notify them that they are considered to be noncompliant. Permits will then be issued at the normal ($100) cost.

**Water Well Records Task Force** The task force currently is processing a backlog of water well permits and logs from wells drilled between 1988 and the present date. This is phase 3 of the catch-up program for water well records. During the past report period, the task force processed 19,733 records from this data set into the main records database. To date, as part of the catch-up program, geological information from 52,055 water well records have been entered into the system.

**Data Acquisition** Oil well permits issued (1,610) by IDMM increased by 330 from last year's 1,280. Oil and water well plugging affidavits decreased during the report period. Of the 3,015 affidavits received, 1,079 were for oil wells (as compared to 1,191 for oil the previous year) and 1,936 for water wells (as compared to 2,160 the previous year). The total of new logs received was 12,528, down from the 13,262 received the previous year. This decrease was partly a result of 3,088 fewer water well logs received during the report period. The following table summarizes GRU activity.

**Annual Statistics of the Geological Records Unit**

| | | |
|---|---|---|
| **Data Acquisition** | | |
| *Basic data* | *1989-90* | *1990-91* |
| Oil permits | 1,280 | 1,610 |
| Water permits | 8,343 | 6,488 |
| Water Task Force records | 19,836 | 19,733 |
| Plugging affidavits - oil | 1,191 | 1,079 |
| - water | 2,160 | 1,936 |
| *Logs* | | |
| Electric logs | 1,211 | 1,517 |
| Micro logs | 215 | 290 |
| Radioactivity logs | 1,417 | 1,517 |
| Miscellaneous geophysical logs | 134 | 227 |
| Total geophysical logs | 2,977 | 3,551 |
| Drillers logs | 149 | 379 |
| Drilling time logs | 254 | 942 |
| Company sample and core studies | 68 | 194 |
| Geologic tops | 202 | 119 |
| General data (completion data) | 1,270 | 1,500 |
| Water well and test hole logs | 7,510 | 4,422 |
| Miscellaneous | 832 | 1,421 |
| Total new logs received | 13,262 | 12,528 |
| **Cumulative Totals** | | |
| **Collections** | **FY91** | **Cumulative to June 30, 1991** |
| Processed drill-hole records | 20,700 | 331,130 |
| Books of processed drill-hole records | 141 | 997 |
| Skeleton logs (records prior to 1920) | | 17,920 |
| Books of skeleton logs | | 40 |
| Books of confidential logs | | 15 |
| Books of out-of-state logs | | 14 |
| Books of misc drill-hole records | | 9 |
| Geophysical logs | 3,551 | 130,773 |
| Coal pluggings | 844 | 22,001 |
| **Service Activities** | **1989-90** | **1990-91** |
| Total mail processed | 26,236 | 23,641 |
| Visitor days | 985 | 1,029 |
| Files used by public and staff | 44,421 | 54,263 |
| Phone calls | 3,345 | 3,581 |
| Copies - continuous logs | 5,475 | 7,216 |
| - single sheets | 39,878 | 49,107 |
| Total orders processed | 1,612 | 1,837 |
| Copies to state agencies/staff - single sheets | 15,637 | 10,099 |
| - logs | 1,032 | 204 |

### Geological Samples Library

ISGS Geological Samples Library (GSL) staff manage one of the largest physical collections of geological samples in the United States. They receive, process for storage, and archive these important collections as mandated by statute (the Illinois Oil and Gas Act (Illinois Revised Statute, Chapter 96½, Paragraph 5409, Section 6). The ISGS began collecting these samples in the early 1900s when the U.S. Geological Survey provided a series of drill cuttings to the State Geologist. Today, this unique repository houses cores and cuttings that represent billions of dollars invested in Illinois by petroleum, mining, and engineering companies. The collection attracts users from across the country, encouraging potential investment in Illinois by both in-state and out-of-state companies, and providing a database with which to address environmental and resources issues.

Visitors and staff referred to our files 224 times (46 less than in FY91) and studied 632 sets of samples or cores (72 more than FY91). Visitors to the Annex facility represent a wide range of geologic interests. Independent consultants and representatives of major oil companies, universities, and government agencies are typical visitors to the Samples Library. Of the 83 (55 less than FY91) visitors to the Samples Library, 40 percent were from out of state. The decline in visitors reflects the continued decrease in oil exploration.

Samples Library staff assemble rock and mineral kits for distribution to Illinois schools. A 35-specimen set is designed to familiarize teachers and students with rocks, minerals, and fossils of Illinois. In the past year, 129 specimen kits (37 more than the previous year) were distributed and 25 orders were filled for the reconditioning of sets.

**Acquisition of Sample Cuttings** Oil and water well cuttings added to the Geological Samples Library during the report period increased the total footage of cuttings to 742,254,119 feet. During FY91, the permanent file of the Samples Library acquired 247 sets of well sample cuttings, representing more than 299,441 feet of drilling. These samples are contained in 502 boxes and occupy an additional 9 linear feet of storage space. Some 291 sets of well cuttings were requested from permits issued last year, as compared with 131 sets from the previous year. The Samples Library files of 67,124 sets of well cuttings are stored in 102,916 boxes and utilize 1,436 linear feet in a 3,780 square foot area of the Samples Library.

Samples from an additional 171 oil and water wells (47 fewer than the previous year) await processing. At present, the interval between receipt and permanent processing is 9 months, a 3-month decrease from last year's processing time. Additions to our permanent files consisted of 107 oil test sets (32 more than the previous year) from rotary drill wells washed, and 140 water wells (19 less than the previous year).

**Cores** Rock cores from oil and mineral borings added to the Geological Samples Library during the report period increased the total footage of core to 1 million feet. During the report period, 135 cores (75 more than the previous year) representing an initial 18,397 feet of drilling were collected, examined, and processed into the permanent files. This year's additions are housed in 256 cardboard core boxes assembled by GSL staff. These cores represent a significant addition to the core collection. The entire collection of 13,618 sets of core on permanent file is stored on steel racks in an area covering approximately 4,300 square feet of the Samples Library. Current capacity for additional core storage at the Annex is only 12,576 total feet of core (3,456 feet of 3-inch core and 9,120 feet of 2-inch core). The Samples Library continues to analyze strategies for receiving and housing additional drill-core samples.

**Other Sample Collections** In cooperation with the Industrial Minerals Section, an additional 783 samples were split and prepared for insoluble residues. The ISGS staff generates a large volume of research material. GSL staff receive, sort, and file these materials in the Staff Research Collections storage area of the Samples Library. Some 789 items, mostly analytical samples, were added to this collection bringing the total to more than 37,265 individual research samples on file at the Annex. Another 4,786 feet of core was received, processed, and placed in temporary storage for ISGS research projects.

The ISGS provides sample bags for the collection of well sample cuttings requested on permits issued by the State. During the report period, the Samples Library supplied drillers and operators with 16,800 sample bags for requested well cuttings (450 less than the previous year). The Samples Library office also houses the ISGS microfiche collection of well log information and sells copies or assists visitors to

examine the collection. During the past report period, 2,786 microfiche were added to the collection, bringing the total to 82,463.

## FY 1991 CAPITAL PROJECTS

An approved FY 1991 capital project continues the Natural Resources Building Laboratory Upgrade Program at a cost of $630,000. The upgrade includes the following laboratories:

**Natural Resources Building**

| Room | Laboratory |
|---|---|
| 5 | Engineering Geology |
| 20 | Isotope Geochemistry |
| 22 | Core Laboratory |
| 26 | Rock Grinding |
| 31 | Industrial Minerals |
| 33 | Industrial Minerals |
| 207 | Mining Geology |
| 217 | Coal Petrography |
| 223 | Low-Temperature Ashing |
| 301 | Petrography |
| 302 | Isotope Geochemistry |
| 311 | Oil and Gas |
| 325 | X-Ray Fluorescence |
| 331 | Furnace Room |
| 335 | Microbial Geochemistry |
| 364 | Mass Spectrometer |
| 403 | Photo Laboratory |
| 425 A | Groundwater Laboratory |
| 425 B | Groundwater Laboratory |
| 435 | Groundwater Laboratory |

Work consists of the following:

- replacing chemical fume hoods and relocating motors and fans to the roof or attic so that fume vents have negative internal pressure through most of their run from workspace to exit vent;
- relocating or installing shower drench stations;
- installing eye and face wash stations;
- replacing laboratory benches and sinks that had corroded plumbing, unsafe and inadequate electrical service, corroded and porous work surfaces, inadequate or unsafe utility service; replacing and improving utilities;
- installing wall cabinets to provide enclosed storage of reagents and glassware, especially where inadequate shelving and other storage space for essential laboratory equipment had resulted in workspace being used for storage;
- replacing old incandescent lights with fluorescent lights to help keep laboratories cool, to avoid the possibility of igniting explosive gases in the event of lamp globe breakage, and to increase the brightness of illumination in the laboratories;
- repainting laboratories with light colors to increase the apparent brightness of room illumination;
- extending the make-up air system;
- removing asbestos.

This project should be completed during the fall of 1991.

# Honors

## HONORS AND AWARDS

### Prizes, Medals, High Offices, and Other Honors

The poster, "Multi-Level GIS Applications in Geologic Mapping," prepared by members of the **Geologic Mapping and Digital Cartography Section**, received a second place award in the "Most Analytical" category at the 1991 ARC/INFO Users Conference, held in Palm Springs, California, May 1991.

**Chen-Lin Chou** was appointed an Adjunct Professor of the Graduate Faculty of Western Kentucky University for the period he is serving on a thesis advisory committee for a graduate student at the University.

**Charles Collinson and Dennis Kolata** were co-recipients of the 1990 Distinguished Achievement Award presented by the ISGS.

**Michael Chrzastowski** was selected by the Executive Committee of Project 274 of the International Geological Correlation Project to be the U.S. representative at the project's 1991 annual symposium from July 23-31, 1991, at Hainan Island in the People's Republic of China.

**Beverly Herzog** was elected for listing in the 17th edition of *Who's Who of American Women.*

**Richard Howard** received a citation from the Potential Gas Committee in October 1990 for his continuous service and loyal support.

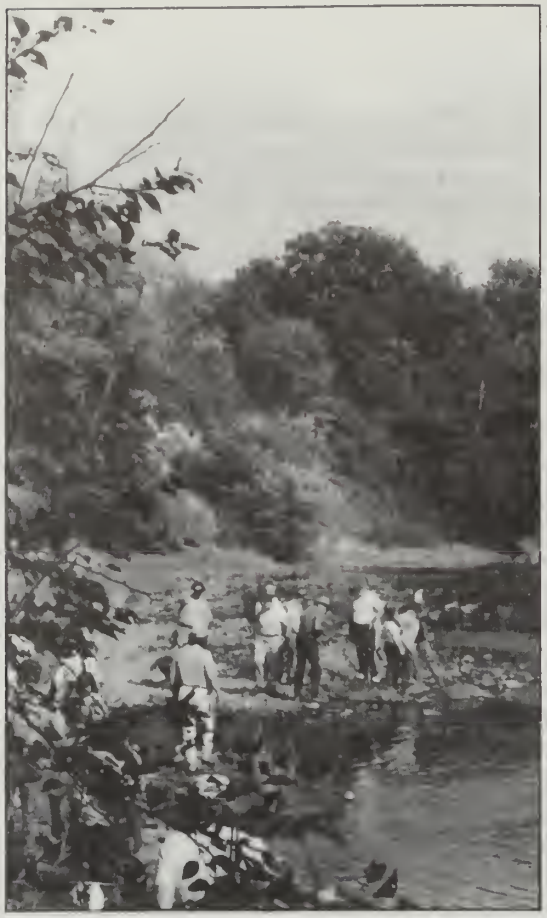
**Hannes Leetaru** was named Outstanding New Staff Member by the ISGS at the annual Retirement and Recognition reception on October 23, 1990.

**Anthony Lizzio** and his co-authors, Hong Jiang and Ljubisa R. Radovic, received an award from Pergamon Press and the American Carbon Society for the best paper published in the journal, *Carbon*, in 1990. The award was presented at the Twentieth Biennial Conference on Carbon at Santa Barbara, California, on June 27, 1991.

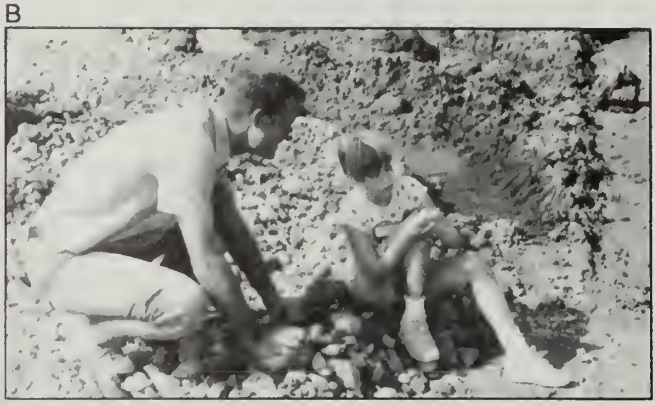
The **Oil and Gas Section** and the **Publications, Graphics, Photography Unit** received Special Achievement Awards for their outstanding contributions during 1989-1990. Each section has contributed in distinctive ways to the benefit of the ISGS and the people of Illinois.

**David Moran and Massoud Rostam-Abadi** were recognized at the ISGS on March 19, 1991, for their high-surface-area hydrated lime invention, which was accepted for development and licensing by Research Corporation Technologies. The invention acceptance payment was also awarded at this special reception.

# Activity Measures



A



B



C



D



E

(A) Decatur geological science field trip participants collect rocks along the Sangamon River at Lincoln Trail Homestead State Park. (B) Geologist James Jennings helps a young girl identify a rock she found at the Vulcan Materials Co. while on the Decatur field trip. (C) Professor Emeritus Larry Sloss (right) of Northwestern University and Chief Morris Leighton review a document before Dr. Sloss delivers the AAPG Distinguished Lecture co-sponsored by the ISGS and the Department of Geology at the University of Illinois. (D) ISGS scientists and other members of the Illinois Geologic Mapping Committee tour the new Collection and Research Center at the State Museum in Springfield. (E) Dennis Kolata (left) receives the Distinguished Achievement Award from Chief Leighton while Charles Collinson, recipient of the Lifetime Distinguished Achievement Award, looks on.

## ACTIVITY MEASURES

All Illinois State Agencies are required to provide activity measures as part of their annual budget presentations to the General Assembly. Selected activity measures also are included in the Governor's report on the Illinois State budget. Internally, we use a wide range of activity measures to gauge how effective we are at reaching the public with our information and services. The measures also are helpful indicators of where our research and service staff are applying their greatest energies, and to what degree we may need to adjust or reshape our program, budget, or organization. The table at the end of this section shows selected activity measures, distributed by program areas.

Some annual activity measures are calculated from samples taken over a period of a few months. For example, the total number of long-distance telephone calls made by our staff is calculated from the total number of calls billed to all our telephones during January, February, and March 1991; the numbers of telephone calls and visitors received by the Information office also are based on a sample count for a short period. We believe that these estimates are sufficient to gauge trends from one year to the next.

### Measures

**Research Activities** ISGS scientists reported 130 state-funded research projects in progress during the year, 29 fewer than last year. Of these, 45 were in the Mineral Resources program, 23 in the Environmental Geology Program, and 61 in General and Basic Research. Our scientists reported that a total of 82 sponsored research projects were active during the year, of which 41 were in the Mineral Resources Program, 33 in Environmental Geology, and eight in General and Basic Research. According to the count maintained by our grants and contracts administrative office, ISGS scientists submitted 93 proposals for sponsored research projects during the year, 14 more than last year. Many proposals are submitted at the request of the sponsoring agency following preliminary negotiations. Consequently, at least 71 percent of the proposals that we submitted were at least partially funded.

To present research information to the public and the scientific community, we published a total of 306 new articles, reports, maps, abstracts, and other formally released documents in our own series and in other forums such as scientific journals, proceedings volumes, and guidebooks. This number is about 23 percent higher than last year. The count includes 22 cross sections for oil-producing counties prepared for the Illinois Department of Mines and Minerals, 12 maps and cross sections prepared for the CUSMAP project, and a limited number of duplicate citations that appear both in scientific journals and in our own reprint series. Also included in the count are 24 individual chapters published in American Association of Petroleum Geologists Memoir 51, *Interior Cratonic Basins*. The Library/Map Room and Information Office sold 8,747 copies of ISGS publications and 2,079 copies of ISGS maps. We distributed 15,770 free copies of our publications, about 1,000 fewer than last year; but we gave away 1,145 copies of maps, almost twice as many as last year. The total of 27,741 copies of our publications distributed this year is about 14 percent less than last year. In addition to our own publications, we sold 19,507 U.S. Geological Survey topographic map products and distributed 2,118 free copies of these products. The number sold this year is about 14 percent less than last year.

### Public, Government, and Industry Services

**Information Responses** As shown in the accompanying table, we met with 6,031 visitors this year to provide scientific information, about a 10-percent decrease from last year. This drop is primarily attributable to substantially fewer visitors reported by our scientists. The Information Office and Geological Records Units received almost 900 more visitors this year. To respond to inquiries and conduct ISGS business, we sent out 1,491 letters (38 percent less than last year's tally) but made 30,236 long-distance telephone calls (26 percent more than last year's tally). Included in the outgoing calls were 3,172 facsimile transmissions, an 100-percent increase over last year's number. The large increases in outgoing long-distance telephone calls (up 52 percent in 2 years) and facsimile transmissions perhaps reflects an increasing sense of urgency in the people's need for geologic information. The Information Office received an estimated 11,250 telephone calls, insignificantly different from last year. Demand for copies of well logs continues to grow, despite the relatively low prices being offered for oil. The Geological Records Unit received 1,029 visitors this year, an increase of 44 as compared to last year; but more than 7,216 continuous copies of well logs were sold. This represents an increase of almost 55 percent over last year. In the last 2 years, the number of log copies sold has more than doubled. The Geological Samples Library received only 113 external visitors this year, as compared to 138 last year. Those visitors used 205 sample sets.

**Identifications, Analyses, and Reports of Results** To conduct various research and service projects during the year, ISGS chemists completed at least 20,176 elemental determinations on 3,198 samples of rock, soil, brine, and water. Other analyses included 1,226 elemental determinations by energy dispersive X-ray analysis with the scanning electron microscope, 2,067 isotopic determinations on 1,465 samples, 138 determinations with the quadrupole mass spectrometer, and 790 elemental determinations on 70 samples of gases evolved during experiments. The ISGS Coal Analysis Laboratory performed 1,300 proximate and ultimate analyses on 272 samples of coal and 250 perchlorethylene extractions on 50 coal samples. Our scientists also completed 3,292 mineralogical determinations by X-ray diffraction, examined 390 thin sections of rocks, performed petrographic analyses on 150 samples of coal and 108 low-temperature ash determinations, identified 235 hand specimens for visitors, examined 78 drill cores and 247 sample sets, and measured 120 stratigraphic sections. Geotechnical analyses included 786 instrumental particle-size determinations on suspended sediments or fine coal, 49 sieve analyses, 102 rock strength tests, 10 determinations of various reservoir engineering parameters, and 21 other miscellaneous determinations. To explore for groundwater and for other purposes, our scientists ran 66 borehole logs at sites in 15 counties, performed 55 electrical earth resistivity surveys in 27 counties, and ran a total of 9 line-miles of seismic profiles. To report the results of these analyses and for other purposes, our scientists prepared 412 unpublished reports, including 83 groundwater possibility reports, six waste disposal site reviews, three ground stability reports, and ten mine subsidence reports. The staff of the Geologic Mapping and Digital Cartography Section and other scientists throughout the ISGS performed 104 data-entry tasks, digitized 455 maps, wrote 1,024 computer programs of various kinds, and plotted out 2,027 digital map files for internal use and external distribution.

**Continuing Scientific/Educational Contributions** ISGS staff members presented papers at scientific meetings, made speeches or other informational presentations at public meetings, discussed posters, participated in field conferences to consider geological problems firsthand with their colleagues, and otherwise transferred information to fellow scientists and the public on 527 occasions during the year, including 112 interviews with print, radio. and television reporters. In addition, our scientists either taught or participated in workshops, seminars and classes on 190 occasions, including a small number of presentations for elementary, secondary, and college classes. We advised graduate students in geology and other fields from across the entire state, nation, and world on at least 283 occasions during the year. The Educational Extension Unit hosted 492 persons on the four public field trips offered this year and distributed 129 complete rock and mineral sets and 35 partial sets to Illinois schools.

**Public, Industry, Government Contributions** Staff members of the ISGS serve on 49 advisory boards for local, state, or national government agencies or citizen groups. Our scientists presented oral or written testimony, or made other kinds of informational presentations to various advisory bodies on 167 occasions during the year. In addition, 101 of our staff hold elective or appointive offices in various professional societies. Through those positions, they provide services to the scientific community, industry, and government by reviewing manuscripts for journals and proposals for funding agencies, organizing and chairing technical sessions at scientific meetings, hosting scientific meetings that bring visitors to the state, devising new standards for analytical methods, and publishing newsletters and summary articles that provide information about scientific, social, and industrial trends.

**Illinois State Geological Survey Selected Activity Measures 1990-91**

| | Mineral Resources | Environmental Geology | General and Basic Research | Administrative Services | Total |
|---|---|---|---|---|---|
| Reports/maps | | | | | |
| Published | 147 | 78 | 66 | 15 | 306 |
| Distributed | | | | | 27,741 |
| Unpublished Reports | 220 | 169 | 23 | -- | 412 |
| Visitors and Office Conferences | 728 | 295 | 266 | 4,742 | 6,031 |
| Letter Responses | 586 | 294 | 161 | 450 | 1,491 |
| Talks, Posters, Displays, and Interviews | 245 | 168 | 73 | 41 | 527 |
| Workshops, Classes, and Seminars | 70 | 60 | 48 | 12 | 190 |

# Financial Report

## FINANCIAL REPORT

### Fiscal Year 1991

**Appropriated Funds** Of the appropriated FY91 funds totaling $6,344,300 (tables F1 and F2), the Illinois State Geological Survey expended all but $800 (0.01%) of General Revenue monies and $79,500 (35.2%) in the Natural Resources Information Fund. Expenditures in the Natural Resources Information Fund were intentionally light as revenues did not fully support the appropriation.

**Allocated Funds** Of the allocated FY91 funds totaling $443,100 (tables F3, F4, and F5), the Illinois State Geological Survey expended all monies in the Building Repair and Maintenance. Lapses occurred in LUMP, $200 (0.15%), and Build Illinois Repair and Maintenance, $300 (0.36%).
The unexpended Build Illinois Equipment funds totalling $5,100 (5.48%) have been reappropriated and will be fully expended in FY92.

**Table F1** FY91 Financial Statement for the Illinois State Geological Survey General Revenue Fund: July 1, 1990, through September 30, 1991. ($ in thousands)

| Line item | Available appropriation for FY91 | Transfers | Vouchered to date | Outstanding obligations this date | Balance available for FY91 |
|---|---|---|---|---|---|
| Personal Services | $5,225.1 | $0.0 | $5,225.1 | $0.0 | $0.0 |
| Retirement Contributions | 418.2 | 0.0 | 418.2 | 0.0 | 0.0 |
| Social Security Contributions | 10.6 | 2.2 | 8.4 | 0.0 | 0.0 |
| Contractual Services | 100.6 | (5.8) | 94.8 | 0.0 | 0.0 |
| Topomapping | 20.3 | 0.0 | 20.1 | 0.0 | 0.2 |
| Travel | 35.6 | (0.3) | 35.3 | 0.0 | 0.0 |
| Commodities | 75.2 | (0.2) | 74.8 | 0.0 | 0.2 |
| Printing | 36.5 | (0.5) | 36.0 | 0.0 | 0.0 |
| Equipment | 32.6 | 0.0 | 32.6 | 0.0 | 0.0 |
| Computer-Based Research | 48.1 | (0.7) | 47.4 | 0.0 | 0.0 |
| Telecommunications | 54.0 | 6.5 | 60.5 | 0.0 | 0.0 |
| Operations of Auto Equipment | 35.1 | 3.2 | 38.3 | 0.0 | 0.0 |
| GeoMapping - Other Expenses | 26.4 | 0.0 | 26.0 | 0.0 | 0.4 |
| TOTALS | $6,118.3 | $0.0 | $6,117.5 | $0.0 | $0.8 |

**Table F2** FY91 financial statement for the Illinois State Geological Survey Natural Resources Information Fund (NRIF): July 1, 1990, through September 30, 1991. ($ in thousands)

| Line item | Appropriation for FY91 | Transfers | Vouchered to date | Outstanding obligations this date | Balance available for FY91 |
|---|---|---|---|---|---|
| Lump Sum - Operating Expenses | $225.0 | 0.0 | $146.4 | $0.0 | $78.6 |
| Refunds | 1.0 | 0.0 | 0.1 | 0.0 | 0.9 |
| TOTALS | $226.0 | 0.0 | $146.5 | $0.0 | $79.5 |

NRIF revenue July 1, 1990 through June 30, 1991 was $134.1.

**Table F3** FY91 Financial Statement for the Illinois State Geological Survey Lands Unsuitable for Mining Program: July 1, 1990 through September 30, 1991. ($ in thousands)

| Line item | Allocation for FY91 | Funds held by DMM | Transfers | Available allocations | Vouchered to date | Outstanding obligations this date | Balance available for FY91 |
|---|---|---|---|---|---|---|---|
| Personal Services | $117.6 | ($0.0) | $0.0 | $117.6 | $117.6 | $0.0 | $0.0 |
| Retirement Contributions | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Social Security Contributions | 0.7 | 0.0 | 0.0 | 0.7 | 0.7 | 0.0 | 0.0 |
| Group Insurance | 9.8 | 0.0 | 0.0 | 9.8 | 9.8 | 0.0 | 0.0 |
| Contractural Services | 0.0 | 0.0 | (0.0) | 0.0 | 0.0 | 0.0 | 0.0 |
| Travel | 3.7 | 0.0 | 0.0 | 3.7 | 3.5 | 0.0 | 0.2 |
| Commodities | 0.0 | 0.0 | (0.0) | 0.0 | 0.0 | 0.0 | 0.0 |
| Printing | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Computer-Based Research | 2.0 | 0.0 | 1.0 | 3.0 | 3.0 | 0.0 | 0.0 |
| Telecommunications | 1.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 0.0 |
| Operations of Auto Equipment | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTALS | $134.8 | ($0.0) | $1.0 | $135.8 | $135.6 | $0.0 | $0.2 |

**Table F4** FY91 financial statement for the Illinois State Geological Survey Groundwater Protection Act: July 1, 1990, through September 30, 1991. ($ in thousands)

| Line item | Appropriation for FY91 | Transfers | Vouchered to date | Outstanding obligations this date | Balance available for FY91 |
|---|---|---|---|---|---|
| Lump Sum | $125.0 | 0.0 | $124.9 | $0.0 | $0.1 |
| TOTALS | $125.0 | 0.0 | $124.9 | $0.0 | $0.1 |

**Table F5** FY91 financial statement for the Illinois State Geological Survey Miscellaneous Funds: July 1, 1990, through September 30, 1991. ($ in thousands)

| Line item | Appropriation for FY91 | Transfers | Vouchered to date | Outstanding obligations this date | Balance available for FY 91 |
|---|---|---|---|---|---|
| Repair & Maintenance—Building | $5.0 | 0.0 | $5.0 | $0.0 | $0.0 |
| Repair & Maintenance—Major Equipment | 84.2 | 0.0 | 83.9 | 0.0 | 0.3 |
| Build Illinois Equipment* | 93.1 | 0.0 | 88.0 | 3.8 | 1.3 |
| TOTALS | $182.3 | 0.0 | $176.9 | $3.8 | $1.6 |

* Reappropriated for FY92.

Illinois Department of Energy and Natural Resources
State GEOLOGICAL SURVEY DIVISION

# PUBLICATIONS

July 1990 to June 1991

# ILLINOIS STATE GEOLOGICAL SURVEY SERIES
**(Released to the Public from July 1, 1990 to June 30, 1991)**

## Bulletins

96 *Geology of the Eddyville, Stonefort, and Creal Springs Quadrangles, Southern Illinois.* 1991. **W.J. Nelson, J.A. Devera, R.J. Jacobson, D.K. Lumm, R.A. Peppers, C.B. Trask, C.P. Weibel, L.R. Follmer, M.H. Riggs,** S.P. Esling (SIU), E.D. Henderson (SIU), and M.S. Lannon (SIU). 1991. 85 pages, 7 tables, 58 figures, 2 plates.

## Circulars

545 *Study of Sulfur Behavior and Removal During Thermal Desulfurization of Illinois Coals.* 1990. **K.C. Hackley, R.R. Frost, C.-L. Liu, S.J. Hawk, and D.D. Coleman.** 33 pages, 22 tables, 24 figures.

547 *Facies Analysis of the Ordovician Maquoketa Group and Adjacent Strata in Kane County, Northeastern Illinois.* 1991. **A.M. Graese.** 36 pages, 1 table, 23 figures.

## Environmental Geology

134 *Numerical Estimates of Potential for Groundwater Contamination from Land Burial of Municipal Wastes in Illinois.* 1990. **B.R. Hensel, R.C. Berg, and R.A. Griffin.** 84 pages, 24 tables, 26 figures.

135 *Investigation of the Hydraulic Effects of Deep-Well Injection of Industrial Wastes.* 1990. **E. Mehnert, C.R. Gendron, and R.D. Brower.** 100 pages, 26 tables, 80 figures. Jointly published with HWRIC as EG 135/HWRIC RR051.

136 *Seismic Reflection and Seismic Refraction Surveying in Illinois.* 1990. **P.C. Helgold.** 52 pages, 1 table, 18 figures.

137 *Geochemical Interactions of Two Deep-Well Injected Wastes with Geological Formations: Long-Term Laboratory Studies.* 1990. **W.R. Roy, B. Seyler, J.D. Steele, D.M. Moore, and I.G. Krapac.** 17 pages, 4 tables, 3 figures.

138 *The Proximity of Underground Mines to Residential and Other Built-up Areas in Illinois.* 1991. **C.G. Treworgy and C.A. Hindman.** 18 pages, 9 tables, 5 figures.

139 *Geotechnical Properties of Selected Pleistocene, Silurian, and Ordovician Deposits of Northeastern Illinois.* 1991. **R.A. Bauer, B.B. Curry, A.M. Graese, R.C. Valden, W.J. Su, and M.J. Hasek.** 92 pages, 27 tables, 25 figures, 15 apps.

## Illinois Minerals

104 *Industrial Minerals and Metals Publications of the Illinois State Geological Survey through December 1989.* 1990. **J.H. Goodwin, D.G. Mikulic, and J.W. Baxter.** 33 pages.

105 *Illinois Mineral Industry in 1988 and Review of Preliminary Mineral Production Data for 1989.* 1990. **I.E. Samson and S.B. Bhagwat.** 43 pages, 25 tables, 13 figures.

106 *Cross Section of the Paleozoic Rocks of Northeastern Illinois: Implications for Subsurface Aggregate Mining.* 1990. **D.G. Mikulic.** 14 pages, 7 figures.

## Illinois Petroleum

134 *Application of Old Electric Logs in the Analysis of Aux Vases Sandstone (Mississippian) Reservoirs in Illinois.* 1990. **H.E. Leetaru.** 21 pages, 19 figures.

136 *Hydrocarbon Source Potential and Organic Geochemical Nature of Source Rocks and Crude Oils in the Illinois Basin.* 1991. **M.-I.M. Chou, D.R. Dickerson, S.-F.J. Chou, and M.L. Sargent.** 39 pages, 11 tables, 14 figures, 5 apps.

**Illinois Geologic Quadrangles (IGQ) and Other ISGS Maps, Cross Sections, Stratigraphic Columns**

IGQ 4 *Geologic Map of the Creal Springs Quadrangle, Illinois.* 1990. **C. B. Trask and R.J. Jacobson.** Full color, scale 1:24,000.

IGQ 5 *Geologic Map of the Eddyville Quadrangle, Illinois.* 1990. **W.J. Nelson and D.K. Lumm.** Full color, scale 1:24,000.

IGQ 6 *Geologic Map of the Stonefort Quadrangle, Illinois.* 1990. **W.J. Nelson and D.K. Lumm.** Full color, scale 1:24,000.

ISGS Map Series *Potential for Aquifer Recharge in Illinois (Appropriate Recharge Areas).* 1990. **D.A. Keefer and R.C. Berg.** Full color, scale 1:1,000,000.

IDMM Cross Section Series *Geologic Framework for Determining Underground Sources of Drinking Water.* 1990. **D.J. Berggren, R.D. Brower, C.A. Chenoweth, A.M. Graese, V.L. Poole, P.C. Reed, E.C. Smith, T. Shaw, J.D. Treworgy, R.C. Valden, and C.P. Weibel.** 22 cross sections from a set of 150 cross sections (identified by county), prepared for Illinois Department of Mines and Minerals.

CUSMAP *Bedrock Geology of the 1° × 2° Paducah Quadrangle* (geologic columns and cross sections). **W.J. Nelson.** Four 40 × 32 inch sheets.

**Monthly Drilling Report**

645-647 *Monthly Report on Oil and Gas Drilling in Illinois.* **B.G. Huff, R.T. Black, and Y. Liu.** July 1990-September 1990. Approx. 18 pages each.

648-656 Monthly Report on Oil and Gas Drilling in Illinois. **B.G. Huff and Y. Liu.** October 1990-June 1991. Approx. 18 pages each.

**Geological Science Field Trip Guide Leaflets**

1990-C *Guide to the Geology of the Oregon Area, Ogle County.* September 1990. **D.L. Reinertsen.**

1990-D *Guide to the Geology of the Nashville Area, Washington County.* October 1990. **D.L. Reinertsen, S.T. Whitaker, P.C. Reed, and L.R. Follmer.**

1991-A *Guide to the Geology of the Fairfield Area, Wayne County.* April 1991. **C.P. Weibel and D.L. Reinertsen.**

1991-B *Guide to the Geology of the Kewanee Area, Henry and Bureau Counties.* May 1991. **D.L. Reinertsen.**

**Educational Series**

13 *Field Guide to Pennsylvanian Fossil Plants of Illinois.* **J.R. Jennings.** 75 pages.

**Guidebook Series**

21 *Wisconsinan and Sangamonian Type Sections of Central Illinois.* 1990. **E.D. McKay.** 48 pages (AMQUA guidebook reissued as an ISGS Guidebook).

22 *Quaternary Records of Northeastern Illinois and Northwestern Indiana.* 1991. **A.K. Hansel** and W.H. Johnson. 106 pages. (AMQUA guidebook reissued as an ISGS Guidebook)

**Open File Series**

1990-2b *Bedrock Topography of Kane County.* 1990. **R.C. Valden and B.B. Curry.** Computer cartography by **A.L. Erdmann**. Scale, 1:62,500.

1990-2c *Drift Thickness of Kane County.* 1990. **A.L. Erdmann.** Developed from Vaiden and Curry (1990). Scale, 1:62,500.

1990-2d *Earth Materials of Kane County.* 1990. **B.B. Curry.** Computer cartography by **A.L. Erdmann.** Scale, 1:62,500.

1990-2f *Soil Drainage Characteristics of Kane County.* 1990. **Mary Greenpool,** with contributions by **A.L. Erdmann and P.J. Zukoski**. Scale, 1:62,500.

1990-2g *Distribution and Thickness of the Tiskilwa Till in Kane County.* 1990. **B.B. Curry.** Computer cartography by **A.L. Erdmann.** Scale, 1:62,500.

1990-3 *3 O'Clock Cross Section in the Illinois Basin: Wayne County, Illinois, to Switzerland County, Indiana.* 1990. **J.D. Treworgy and S.T. Whitaker.** Vertical scale, 1 in. = 400 ft; horizontal scale, 1:250,000.

1990-4 *9 O'Clock Cross Section in the Illinois Basin: St. Clair County to Wayne County, Illinois.* 1990. **S.T. Whitaker and J.D. Treworgy.** Vertical scale, 1 in. = 400 ft; horizontal scale, 1:250,000.

1990-5 *1 O'Clock Cross Section in the Illinois Basin: Wayne County, Illinois, to Lake County, Indiana.* 1990. **J.D. Treworgy and S.T. Whitaker.** Vertical scale 1 in. = 400 ft; horizontal scale 1:250,000.

1990-7 *Upgrading Mild Gasification Oils.* 1990. Michael D. Stephenson. 34 pages.

1990-8 *The Superconducting Super Collider Collection: Bibliography and Archival Listing of Materials at the Illinois State Geological Survey.* 1990. **P. G. Wasson.** 98 pages.

1990-9 *Kane County Water Well Database.* 1990. **J.J. Eidel, A.P. Visocky, and C.J. Zelinsky**. 214 pages, 16 figures.

1990-10 *Key Stratigraphic Control: SSC Area.* 1990. **J.P. Kempton,** with assistance from **J.L. Hannah and M.J. Mushrush**. 42 pages, 2 plates.

1990-11 *Field Study of Transit Time Through Compacted Clays—Interim Annual Contract Report for the Period July 1, 1989 to June 30, 1990.* **K. Cartwright, I.G. Krapac, S.V. Panno, B.L. Herzog, B.R. Hensel** and K.R. Rehfeldt. 34 pages.

1991-1 *Quaternary Geology of the Martinsville Alternative Site, Clark County, Illinois.* 1991. **B.B. Curry, R.C. Berg, and M.R.T. Cartwright.** 148 pages, 4 tables, 29 figures, 1 app.

1991-2 *Quaternary Lithostratigraphy of the Martinsville Area North to the Martinsville Alternative Site.* 1991. **B.B. Curry, R.C. Berg, and M.R.T. Cartwright.** 68 pages, 2 tables, 23 figures, 1 app.

1991-3 *Characterization of the Organic Sulfur in Macerals and Chars.* 1991. Final contract technical report to the Center for Research on Sulfur in Coal. **R.D. Harvey, I. Demir and D.D. Bannerjee**. 25 pages.

1991-4 *A Method for Improving Sulfur Capture Using Coal/Sorbent Pellets.* 1991. Final contract technical report to the Center for Research on Sulfur in Coal. **D.M. Rapp.** 35 pages.

1991-5 *Benefits and Costs of Geologic Mapping Programs in Illinois: The Case of Boone and Winnebago Counties and Its Statewide Applicability.* 1991. **S.B. Bhagwat and R.C. Berg**. 57 pages.

1991-6 *Advanced Physical Fine Coal Cleaning by ISGS Aggregate Flotation.* 1991. **J.M. Lytle**. 57 pages.

1991-10 *Correlation of Upper Pennsylvanian Bedrock Strata at the Proposed Low-Level Radioactive Waste Disposal Facility at the Geff Alternative Site, Wayne County, Illinois.* 1991. **C.P. Welbel.** 39 pages, 2 cross sections as separate plates.

**Reprints**

1990-D *Geology of the Herrin Coal at the Crown II Mine, Virden, Macoupin County, Illinois.* **P.J. DeMaris and W. J. Nelson**. 9 pages, 8 figures.

1990-E *Coal: World Resources.* **H.H. Damberger**. 9 pages, 6 figures.

1990-F *Coal: Geology.* **R.D. Harvey**. 6 pages.

1990-G *Abundance and Origin of Major Minerals in the Herrin Coal, Illinois Basin.* **I. Demir and R.D. Harvey**. 10 pages, 6 figures.

1990-H *Abundances and Leachabilities of Sodium and Chlorine in Lithotypes of Illinois Basin Coals.* **I. Demir, C.-L. Chou, and C. Chaven**. 13 pages, 14 figures.

1990-I *Particle-Size Analysis by a Modified Pipette Procedure.* S.J. Indorante, **L.R. Follmer,** R.D. Hammer, and P.G. Koenig. 4 pages, 2 figures.

1990-J *Late Wisconsinan and Holocene Littoral Drift Patterns in Southern Lake Michigan.* **M.J. Chrzastowski**. 6 pages, 3 figures.

1990-K *Estimate of the Natural-State Littoral Transport Along the Chicago Lakeshore.* **M.J. Chrzastowski**. 8 pages, 4 figures.

1990-L *1989 Shore Erosion and Rapid Development of Logarithmic-Spiral Recession at North Point Marina, Lake County, Illinois.* **M.J. Chrzastowski and P.D. Terpstra**. 5 pages, 3 figures.

1990-M *Geochemistry of Sulfur in Coal.* **C.-L. Chou**. 23 pages, 5 figures.

1990-N *Fluvial-Estuarine Valley Fill at the Mississippian-Pennsylvanian Unconformity, Main Consolidated Field, Illinois*, **R.H. Howard and S.T. Whitaker**. 23 pages, 23 figures.

1991-A *Evidence for Post-Two Creeks Age of the Type Calumet Shoreline of Glacial Lake Chicago.* A.F. Schneider and **A.K. Hansel**. 8 pages, 10 figures.

1991-B *Construction and Performance of a Long-Term Earthen Liner Experiment.* **K. Cartwright and I.G. Krapac.** 21 pages, 5 figures.

1991-C *Impact of Riverine Wetlands Construction and Operation on Stream Channel Stability: Conceptual Framework for Geomorphic Assessment.* B.L. Rhoads and **M. V. Miller**. 9 pages, 5 figures.

1991-D *Numerical Assessment of a Landfill Compliance Limit.* **B. R. Hensel, D. A. Keefer, R. A. Griffin, and R. C. Berg**. 7 pages, 5 figures.

1991-E *Memorial to Walter Henry Voskuil, 1892-1984.* **J. A. Simon**. 6 pages.

1991-F *Memorial to Hubert Elias Risser, 1914-1974.* **J. A. Simon**. 4 pages.

1991-G *Memorial to Harold Bowen Willman, 1901-1984.* **J. A. Simon and E. Atherton**. 8 pages.

1991-H *Evidence for the Intra-Glenwood (Mackinaw) Low-Water Phase of Glacial Lake Chicago.* G. W. Monaghan and **A. K. Hansel**. 6 pages, 2 figures.

1991-I *The Building, Deterioration, and Proposed Rebuilding of the Chicago Lakefront.* **M. J. Chrzastowski**. 9 pages, 13 figures.

1991-J *Leaching Behavior of Fine-Coal Cleaning Waste Solids.* **G. B. Dreher, W. R. Roy, and J. D. Steele**. 8 pages, 3 figures.

**Special Publications**

*Geologic Mapping for the Future of Illinois.* 1991. **H.H. Damberger, M.W. Leighton, and others**. 55 pages, 50 figures.

*ISGS 1989-90, Science on Energy, Groundwater Protection.* **S. Muckensturm.** 32 pages, 1 figure, 21 photos.

*Geonews.* Summer 1990. Winter 1991.

*1990 Additions to the Geological Samples Library.* **C.J. Zelinsky**

*Illinois State Geological Survey Annual Report, July 1990 - June 1991.* 180 pages, 45 photos.

**Final Contract Reports and Other Public Documents**

**Bauer, R.A.,** C.H. Dowding, **D.J. Van Roosendaal, B.B. Mehnert,** M.B. Su, and K. O'Connor, 1991, Application of time domain reflectometry to subsidence monitoring: *Final contract report to U.S. Office of Surface Mining for Assistance Agreement No. HQ51-CT6-01537*, 48 p.

**Chou, C.-L.,** C.A. Woodward, **and C. Chaven**, 1990, Production of super-clean coal by wet-grinding and selective flocculation: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL, 30 p.

**DeBarr, J.A., M. Rostam-Abadi, R.D. Harvey,** S.A. Benson, and D. Toman, 1990, Reactivity and combustion characteristics of coal-char blend fuels: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Ehrlinger, III, H.P., D,M. Rapp, C.W. Kruse, C. Chaven, M. Rostam-Abadi**, P. Chow and R.C. Strickland, 1990, Particle size enlargement of fine coal or char using lignocellulosic residue from TVA's biomass program: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Ehrlinger, III, H.P., J.M. Lytle. S.B. Bhagwat, L.B. Kohlenberger, S. Keithly, L.A. Khan**, K. Ghiassi, D. Kendrick, R. Stermer, and J.D. Stephenson, 1990, Column vs subaeration cells for the flotation of fine coal from plant waste: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

FitzPatrick, J., **J.B. Risatti,** and B.T. You, 1990, Microbial suppression of pyrite from Illinois coals: new reagents and scale-up: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL, 35 p.

**Harvey, R.D., and I. Demir**, 1990, Characterization of the organic sulfur in macerals and chars: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL, 25 p.

**Herzog, B.L., et al.**, 1990, Annual Report, Aquifer Assessment Program: *Report to the Illinois Department of Energy and Natural Resources*, Springfield, IL.

**Herzog, B.L., and P.R. Seaber**, 1991, Ground-water and surface-water relationships in Illinois: *in* Instream Flow Protection Committee, *A Plan for Protecting Illinois Instream Flow Resources*, A report to the Governor and the General Assembly, Illinois Department of Transportation, Division of Water Resources, Springfield, IL, Appendix B, 9 p.

Kovacic, D.A., T.J. Bicki, and **R.A. Cahill**, 1990, An evaluation of yard waste composting with regard to pesticides and other toxic residues: *Final Contract Technical Report to the Office of Solid Waste Research, University of Illinois Center for Solid Waste Management and Research*, Contract OSWR 02-11, 450 p.

**Kruse, C.W., C. Chaven, P. Ehrlinger, III, D.M. Rapp, J.C. Hurley**, and K.S. Vorres, 1990, Illinois Basin Coal Sample Program: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Kruse, C.W.,** C.W. Knudson, **H.P. Ehrlinger, III, M. Rostam-Abadi, C. Felzoulof,** C.R. Porter, T. Uzkan, R.C. Bourke, and R.C. Strickland, 1990, Lignin-augmented bituminous coal depolymerization: a route to clean fuels: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Kruse, C.W., and A.D. Williams**, 1990, Production of premium liquids by mild gasification: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Rapp, D.M., J.M. Lytle, M. Rostam-Abadi, K.C. Kackley, L.B. Kohlenberger, D.L. Moran,** M.J. Demers, P.M. Murphy, R.L. Berger, and K. Griggs, 1990, A method for improving sulfur capture using coal-sorbent pellets: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Reed, P.C., and P.G. Orozco**, 1990, Report on natural gamma logging of Hanson Engineers Observation Wells M-01C; M-01D; A1-3; B-1-4; C-1-4; D-1; E-1-4; F-1; G-1; H-1; and Philip B. Reed's Farm Well, Sections 29 and 31, T10N, R13W, Clark County, IL: *Contract Technical Report submitted to Hanson Engineers*, Springfield, IL, 7 p.

**Rostam-Abadi, M., D.L. Moran, and R.D. Harvey**, 1990, Evaluation of high surface area hydrated lime for $SO_2$ control: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL.

**Trask, C.B.**, 1990, Information system on Illinois coal VI: ICBIB maintenance and promotion: *Final Contract Technical Report for the period September 1, 1989 to August 31, 1990, Center for Research on Sulfur in Coal*, Carterville, IL, 4 p.

## EXTERNAL PUBLICATIONS

### Abstracts

Bergstrom, S.M., W.D. Huff, and **D.R. Kolata**, 1991, Ordovician K-bentonites in the Iapetus region: stratigraphic and geographic distribution and trans-Atlantic relationships: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 4.

Blackwell, B., H.P. Schwarcz, J.J. Saunders, N. Woodman, and **B.B. Curry**, 1990, Dating the Sangamon: electron spin resonance (ESR) dating of mammal teeth and gar scales from Hopwood Farm, Montgomery County, Illinois: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A85.

Buchanan, D.H., R. Marchant, K. Puharich, L. Warfel, **C. Chaven, K.C. Hackley, and C.W. Kruse**, 1990, Organic sulfur removal from Illinois coal: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Center for Research on Sulfur in Coal, Carterville, IL, p. 23.

**Chou, C.-L.**, 1990, Production of superclean coal by wet-grinding and selective flocculation: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 18.

**Chou, C.-L.**, 1990, Formation of pyrite and organic sulfur in coal: a review: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A202.

**Chou, C.-L.**, 1991, Distribution and forms of chlorine in Illinois Basin coals: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 7.

**Chrzastowski, M.J.,** D.W. Folger, C.F. Polloni, F.A. Pranschke, and C.W. Shabica, 1990, Geologic setting of the Olson tree site, southern Lake Michigan: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A85.

**Chrzastowski, M.J., and P.D. Terpstra**, 1991, Monitoring of 1989-90 beach and nearshore geomorphic changes at North Point Marina, Winthrop Harbor, Illinois: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 7.

**Chrzastowski, M.J.,** and T.A. Thompson, 1991, Coastal evolution of the southern shore of Lake Michigan since late Wisconsinan time: *in* J.F. Donoghue et al., eds., *Program and abstracts, Research Conference on Quaternary Coastal Evolution*, SEPM/Society for Sedimentary Geology, Tulsa, OK, pp. 24-25.

**Cole, Robert D.**, 1991, Preliminary paleogeographic reconstruction of the Illinois Basin during deposition of the Mississippian Aux Vases Formation: Implications for hydrocarbon recovery: *American Association of Petroleum Geologists Bulletin*, V. 75, N. 3, p. 555.

**Coleman. D.D., and C.-L. Liu**, 1991, Identification of landfill gas using radiocarbon dating: *Radiocarbon*, V. 33, N. 2, p. 187.

**Curry, B.B.** and R.M. Forester, 1991, Paleoenvironments and lithology of the Hopwood Farm site, Montgomery County, Illinois: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 9.

**Damberger, H.H.**, Peat-penecontemporaneous rivers in the Pennsylvanian of the Illinois Basin: The evolution of a concept and its economic significance: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A16.

**DeBarr, J.A., M. Rostam-Abadi,** S.A. Benson, D. Toman, and M. Steinberg, 1990, Combustion characteristics of coal-char blend fuels: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting,* Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 11.

**Dixon, Jr., W.G., T.P. Adams, A.L. Erdmann, and M.S. Summers**, 1990, Assessing environmental risk in an urban environment: *Program and abstracts for the annual meeting, Association of Engineering Geologists,* Pittsburgh, PA, p. 80.

**Ehrlinger, III, H.P., J.M. Lytle, S.B. Bhagwat, L.B. Kohlenberger, S. Kelthley**, R.M. Sterner, and A.J. Jonaitis, 1990, Column vs subaeration cells for the flotation of fine coal from plant waste: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 17.

**Ehrlinger, III, H.P., D.M. Rapp, C.W. Kruse, C. Chaven, M. Rostam-Abadi**, P. Chow, and R.C. Strickland, 1990, Particle size enlargement of fine coal of char using lignocellulosic residue from TVA's biomass program: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 22.

FitzPatrick, J., and **J.B. Risatti**, 1990, Microbial suppression of pyrite from Illinois coals: new reagents and scale-up: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 26.

**Goodwin, J.H., and D.L Reinertsen**, 1991, Resources for teaching geology available from the Illinois State Geological Survey: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 14.

Grimley, D.A., W.H. Johnson, and **L.R. Follmer**, 1991, Stratigraphy and magnetic susceptibility of four Quaternary loesses and paleosols near Thebes, Illinois: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. A15.

**Hackley, K.C., C.-L. Liu, and D.D. Coleman**, 1991, Radiocarbon dating of groundwater containing microbial methane: *Radiocarbon*, V. 33, N. 2, p. 204.

**Harvey, R.D., and I. Demir**, 1990, Characterization of organic sulfur in macerals and chars: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 32.

Heckel, P.H., J.E. Barrick, D.R. Boardman, L.L. Lambert, W.L Watney, and **C.P. Welbel**, 1991, Biostratigraphic correlation of eustatic cyclothems (basic Pennsylvanian sequence units) from midcontinent to Texas and Illinois: *American Association of Petroleum Geologists Bulletin*, V. 75, N. 3, p. 592.

**Hensel, B.R., K. Cartwright, I.G. Krapac, and S.V. Panno**, 1990, Moisture movement in an experimental soil liner: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A63.

**Hughes, R.E., D.M. Moore**, T.M. Berres, and K.B. Farnsworth, 1990, Berthierine pipestones of Native Americans in the mid-continent: *Abstracts with Programs, 27th Annual Meeting, Clay Minerals Society*, University of Missouri, Columbia, MO, October 6-11, 1990, p. 64.

**Hughes, R.E., D.M. Moore, and H.D. Glass**, 1990, The nature, detection, occurrence and origin of kaolinite/smectite: *Abstracts with Programs, 27th Annual Meeting, Clay Minerals Society*, University of Missouri, Columbia, MO, October 6-11, 1990, p. 65.

**Hughes, R.E., D.M. Moore, and H.D. Glass**, 1990, Qualitative and quantitative analysis of clay minerals in soils: *Abstracts with Program,* Soil Science Society of America, San Antonio, TX, October 21-26, 1990., p. 350.

Johnson, W.H., **A.K. Hansel, L.R. Follmer, and B.B. Curry**, 1991, Late Quaternary temporal classification in Illinois: Geochronologic or diachronic: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. A19-A20.

**Killey, M.M., and C.B. Trask**, 1990, Expert stratigraphic interpretation of water well logs and sample sets provides valuable data for environmental projects: *Abstracts and Program, 33rd Annual meeting, Association of Engineering Geologists*, Pittsburgh, PA, p. 95.

**Killey, M.M., N.P. Schneider,** and B.C. Kimpel, 1990, Resource recovery and wetland preservation: implications for impact from a sand and gravel operation in northeastern Illinois: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 21.

Kluessendorf, J., and **D.G. Mikulic**, 1990, Temporal, ecological and environmental trends in Phanerozoic soft-bodied fossil Lagerstätten: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A308.

**Kolata, D.R., and P.C. Helgold**, 1991, Proterozoic crustal domain boundary at the southern end of the Illinois Basin: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 22.

**Kruse, C.W., C. Chaven, H.P. Ehrlinger, III, K.C. Hackley, D.M. Rapp, and J.C. Hurley**, 1990, Illinois Basin coal sample program: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 35.

**Kruse, C.W., H.P. Ehrlinger, III, M. Rostam-Abadi, C. Felzoulof**, C.L. Knudson, C.R. Porter, T. Uzkan, R. C. Bourke, and R. C. Strickland, 1990, Lignin-augmented bituminous coal depolymerization: a route to clean fuels: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 7.

**Kruse, C.W., A.D. Williams, and C. Felzoulof**, 1990, Production of premium liquids by mild gasification: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 2.

**Liu, C.L., K.C. Hackley, D.D. Coleman, L. Kroitoru, and S. Cheng**, Effect of microbial methane formation on the $\delta^{13}C$ value and radiocarbon age of dissolved inorganic carbon (DIC) in groundwater: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A123.

**Lizzio, A.A.**, H. Jiang, and L.R. Radovic, 1990, A temperature-programmed desorption and transient kinetics study of noncatalytic char gasification: Proceedings of the American Institute of Chemical Engineers Annual Meeting, Chicago, IL, November 1990.

**Mikulic, D.G.**, and J. Kluessendorf, 1991, Silurian reef development along the western edge of the Michigan Basin: *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 48.

**Moore, D.M., and R. E. Hughes**, 1990, The clay mineralogy of two Mississippian sandstone reservoirs in the Illinois Basin: *Abstracts with Program, 27th Annual Meeting, Clay Minerals Society*, University of Missouri, Columbia, MO., October 6-11, 1990, p. 90.

**Moore, D.M., and R.E. Hughes**, 1990, Varieties of chlorites and illites and porosity in Mississippian sandstone reservoirs in the Illinois Basin: *American Association of Petroleum Geologists Bulletin*, V. 75, N. 3, p. 174-175.

**Oltz, D.F., H.W. Bang, H.E. Leetaru, B. Seyler, and S.T. Whitaker**, 1990, An integrated approach to reservoir characterization in the Illinois Basin: *Proceedings of the First Annual Archie Conference*, Houston, TX, Oct. 22-25, 1990.

**Panno, S.V., K. Cartwright, B.R. Hensel, I.G. Krapac,** K.H. Rehfeldt, and **B.L. Herzog**, 1990, Infiltration of water in a field-scale compacted soil liner: two years of monitoring: *Proceedings of the Conference on Solid Waste Research in the Midwest*, Chicago, IL, October 26-27, 1990, Illinois Department of Energy and Natural Resources, Springfield, IL, pp. 8-9.

**Panno, S.V., and D.M. Moore**, 1990, Alteration of clay minerals in shale of the Davis Formation, southeast Missouri: *Abstracts with Program, 27th Annual Meeting, Clay Minerals Society*, University of Missouri, Columbia, MO, October 6-11, 1990, p. 101.

**Rapp, D.M., K.C. Hackley, J.M. Lytle, D.L. Moran, L.B. Kohlenberger, M. Rostam-Abadi**, R.L. Berger, and K.L. Griggs, 1990, A method for improving sulfur capture using coal/sorbent pellets: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 10.

**Reed, P.C., W. J. Morse,** and S.J. Cravens, 1990, Lithologic character of the Silurian bedrock aquifer near Leesville in northeastern Iroquois County, Illinois: *Transactions of the Illinois State Academy of Science*, Supplement to Volume 83. Abstracts for the 83rd Annual meeting, October 26-27, 1990, Urbana, p. 46.

**Rostam-Abadi, M., D.L. Moran**, H. Yoon, J.A. Withum, S.J. Bortz, and M.J. Rood, 1990, Evaluation of high surface area hydrated lime for $SO_2$ control: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 39.

**Roy, W.R.**, 1991, Geochemical modelling and transformation of two injection-well wastes: long-term laboratory studies: *EOS*, Transactions of the American Geophysical Union, Program and Abstracts, Spring meeting, Baltimore, MD, May 28–June 1, 1991, pp. 110-111.

**Seyler, B.**, 1990, Aux Vases Sandstone reservoir at Zeigler Field, Franklin County, Illinois: *American Association of Petroleum Geologists Bulletin*, V. 74, N. 8, p. 1310.

**Seyler, B., D.S. Beaty, and B.G. Huff**, 1991, Aux Vases Sandstone diagenesis: applications for hydrocarbon recovery from southern Illinois Reservoirs: *Bulletin of the American Association of Petroleum Geologists*, V.75, No. 3, p. 670.

**Shablca, C.W., F.A. Pranschke, and M.J. Chrzastowskl**, 1991, Sediment entrapment by coastal structures along the Illinois shore of Lake Michigan: *Program and Abstracts, 34th Conference on Great Lakes Research*, International Association for Great Lakes Research, p. 76.

**Terpstra, P.D., and M.J. Chrzastowskl**, 1991, Summary of lake bottom changes at North Point Marina vicinity between 1988 and 1990: *Program and abstracts, 34th Conference on Great Lakes Research*, International Association for Great Lakes Research, Buffalo, NY, p. 76.

**Trask, C.B., and R.D. Harvey**, 1990, Information system on Illinois coal VI: ICBIB maintenance: *Abstracts of Papers, Eighth Annual Contractors' Technical Meeting*, Illinois Coal Development Board, Center for Research on Sulfur in Coal, Carterville, IL, p. 36.

**Trask, C.B., M.M. Killey, and J.P. Kempton**, 1990, Thirty years of applied Quaternary studies at the Illinois State Geological Survey: development of key concepts: *Abstracts and Program*, First Joint Meeting of the Canadian and American Quaternary Associations (CANQUA/AMQUA), Waterloo, Ontario, Canada.

**Treworgy, J.D., M.L. Sargent, and D.R. Kolata**, 1991, Tectonic subsidence history of the Illinois Basin: in *Program with Abstracts for the Louis Unfer, Jr., Conference on the Geology of the Mid-Mississippi Valley*, June 13-14, 1991, Southeast Missouri State College, Cape Girardeau. MO.

Troost, K.G., and **B.B. Curry**, 1990, Quaternary sand and gravel in glacigenic sediments at the Martinsville Alternative Site, a proposed low-level radioactive waste disposal site in Clark County, Illinois: *Geological Society of America, Abstracts with Programs*, V. 22, N. 7, p. A281.

**Welbel, C.P.**, 1991, Cyclothem revival! (Sequence stratigraphy of Upper Pennsylvanian strata, east-central Illinois): *Geological Society of America, Abstracts with Programs*, V. 23, N. 3, p. 65.

**Weibel, C.P., and R.C. Berg**, 1990, Case history of site characterization of bedrock stratigraphy of the Geff Alternative Site for low-level radioactive waste disposal, Wayne County, Illinois: *Geological Society of America, Abstracts with Programs*, Vol. 22, No. 7, p. A281.

**Whitaker, S.T., and H.E. Leetaru**, 1991, A comparison of reservoir heterogeneity and recovery efficiency of two offshore marine bar complexes in an intracratonic basin: *American Association of Petroleum Geologists Bulletin*, V. 75, N. 3, p. 692.

### Articles in Peer Reviewed Journals

Ballestero, T., **B. Herzog**, O. Evans, and G. Thompson, 1991, Chapter 4, Monitoring and sampling in the vadose zone: *in* D.M. Nielsen and G.L. Yeates, eds., *Ground Water Monitoring*, Lewis Publishing, Chelsea, MI, pp. 97-141.

Bethke, C., J.D. Reed, and **D.F. Oltz**, 1991, Chapter 26, Long-range petroleum migration in the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 455-472.

Bethke, C., J.D. Reed, and **D.F. Oltz**, 1991, Long-range petroleum migration in the Illinois Basin: *American Association of Petroleum Geologists Bulletin*, V. 75, pp. 925-945.

Boardman, D.R., P.H. Heckel, J.E. Barrick, M.N. Nestell, and **R.A. Peppers**, 1991, Middle-Upper Pennsylvanian chronostratigraphic boundary in the midcontinent region of North America: *in* P.L. Brenckle and W.L. Manger, eds., *International Correlation and Division of the Carboniferous System*, Courier Forschungsinstitut Senckenburg, Frankfurt 130, pp. 319-338.

**Buschbach, T.C., and D.R. Kolata**, 1991, Chapter 1, Regional setting of the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 29-55.

**Cartwright, K., and I.G. Krapac**, 1990, Construction and performance of a long-term earthen liner experiment: *in* R. Bonapart, ed., *Waste Containment Systems: Construction, Regulation and Performance*, American Society of Civil Engineers, Geotechnical Special Publication No. 26, New York, NY, pp. 135-155.

Catt, J.A., **L.R. Follmer**, A. Bronger, P. Bullock, J.B. Dalrymple, H. Muecher, H. Polach, J. Rose, and D.H. Yaalon, 1990, Paleopedology manual: *Quaternary International*, V. 6, 95 p.

**Chrzastowski, M.J.**, 1991, The building, deterioration and proposed rebuilding of the Chicago lakefront: *Shore and Beach, Journal of the American Shore and Beach Preservation Association*, V. 59, N. 2, pp. 2-10.

**Chrzastowski, M.J.**, 1991, Late Holocene coastal evolution of the central Chicago lakeshore and model for related evolution of the Chicago River: *in* D.W. Folger, S.M. Colman and P.W. Barnes, eds., *Third Annual Southern Lake Michigan Coastal Erosion Workshop*, U.S. Geological Survey Open-File Report 91-284, pp. 19-21.

**Curry, B.B.,** and W.N. Melhorn, 1990, Summit Lake landslide and geomorphic history of Summit Lake basin, northwestern Nevada: *Geomorphology*, V. 4, pp. 1-17.

**Damberger, H.H.**, 1990, Coal: World Resources: *in* D.D. Carr and N. Herz, eds., *Concise Encyclopedia of Mineral Resources*, Pergamon Press, New York, NY, pp. 46-55.

**Devera, J.A.,** and N.R. Hasenmueller, 1991, Chapter 8, Kaskaskia Sequence: Middle and Upper Devonian Series through Mississippian Kinderhookian Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 113-124.

**Dreher, G.B., W.R. Roy, and J.D. Steele**, 1991, Leaching behavior of fine-coal cleaning waste solids: *Journal of Coal Quality*, V. 10, N. 1, p. 29-36.

**Eidel, J.J.**, 1991, Basin analysis for the mineral industry: *in* E.R. Force, **J.J. Eidel**, and J.B. Maynard, eds., Sedimentary and diagenetic mineral deposits: a basin analysis approach to exploration: *Society of Economic Geology Reviews in Economic Geology*, V. 5, pp 1-15.

**Frost, J.K.**, 1991, Determination of elemental concentrations in nine CMEA rock and ore standards, in NBS 98 plastic clay, and in fired clay Gent (FCG) by instrumental neutron activation analysis: *Geostandards Newsletter*, V. 15, pp. 43-50.

Force, E.R., **J.J. Eidel,** and J.B. Maynard, eds., 1991, Sedimentary and diagenetic mineral deposits: a basin analysis approach to exploration: *Society of Economic Geology Reviews in Economic Geology*, V. 5, 216 p.

Hatch, J.R., **J.B. Risatti,** and J.D. King, 1991, Chapter 24, Geochemistry of Illinois Basin oils and hydrocarbon source rocks: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 403-423.

**Heigold, P.C.,** 1991, Chapter 17, Crustal character of the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 247-262.

**Heigold, P.C., and D.F. Oltz**, 1991, Chapter 12, Seismic expression of the stratigraphic succession: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 169-178.

**Hensel, B.R., D.A. Keefer, R.A. Griffin, and R.C. Berg**, 1991, Numerical assessment of a landfill compliance limit: *Ground Water*, V. 29, N. 2, pp. 218-224.

**Herzog, B.L., and R.A Griffin**, 1990, Investigation of failure mechanisms and migration of industrial chemicals at Wilsonville, IL, *U.S. Environmental Protection Agency Environmental Research Brief*, U.S. EPA Risk Reduction Laboratory, Cincinnati, OH, EPA/600/M-89/033, 7 p.

**Herzog, B.L.,** J. Pennino, and G.L. Yeates, 1991, Chapter 11, Ground-water sampling, *in* D.M. Nielsen and G.L. Yeates, eds., Ground Water Monitoring, Lewis Publishing, Chelsea, MI, pp. 449-499.

**Howard, R.H.**, 1991, Chapter 21, Hydrocarbon reservoir distribution: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins,* American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 299-328.

Hoyt, W.H., J.C. Kraft, and **M.J. Chrzastowski**, 1990, Prospecting for submerged archaeological sites on the continental shelf: southern mid-Atlantic bight of North America: *in* J. Donahue and N. Lasca, eds., *Archaeological Geology*, Geological Society of America, Decade of North American Geology, V. 4, pp. 147-160.

**Huff, B.G.**, 1989 (published 3/91), Reports from states and official observers: *Interstate Oil Compact & Committee Bulletin*, V. 4, N. 1, pp. 105-106.

**Huff, B.G.**, 1991, Annual review, Illinois: *Northeast Oil World*, V. 11, N. 6, pp. 14-15.

**Huff, B.G.,** B.C. Nuttall, D.M. Sullivan, and M. Berwind, 1990, Oil and gas developments in the east-central states in 1989: *American Association of Petroleum Geologists Bulletin*, V. 74, N. 10B, pp. 61-70.

Huff, W.D., and **D.R,. Kolata**, 1990, Correlation of the Ordovician Deicke and Millbrig K-bentonite between the Mississippi valley and the southern Appalachians: *American Association of Petroleum Geologists Bulletin*, V. 74, N. 11, pp. 1736-1747.

Idoranti, S.O., R.D. Hammer, and **L.R. Follmer**, 1990, A modified method of particle-size analysis: *Soil Science Society of America Journal*, V. 54, N. 2, pp. 560-563.

Kluessenfdorf, J., and **D.G. Mikulic**, 1990, Temporal patterns in the Arthropod fossil record: *Short courses in paleontology: Arthropod paleobiology*, Paleontological Society Special Publication No. 3, pp. 66-98.

Kluessendorf, J., and **D.G. Mikulic**, 1991, Soft-bodied fossils from the Silurian of Wisconsin: *Mid-America Paleontological Society Digest*, p. 108-115.

**Kolata, D.R.**, 1991, Chapter 2, Overview of sequences: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 59-73.

**Kolata, D.R.**, 1991, Chapter 4, Tippecanoe sequence overview: Middle Ordovician through Lower Ordovician Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, p. 87.

**Kolata, D.R.**, 1991, Chapter 14, Illinois Basin geometry: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 197.

**Kolata, D.R., and W.J. Nelson**, 1991, Chapter 18, Tectonic history of the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 263-285.

**Kolata, D.R., and W.J. Nelson**, 1991, Chapter 19, Basin-forming mechanisms of the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 287-292.

**Kolata, D.R.,** and M.C. Noger, 1991, Chapter 5, Tippecanoe I subsequence: Middle and Upper Ordovician Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 89-99.

**Kolata, D.R.,** and W.W. Olive, 1991, Chapter 11, Zuni and Tejas sequences: Late Cretaceous through Holocene Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 165-168.

**Krapac, I.G., K. Cartwright, S.V. Panno, B.R. Hensel,** K.H. Rehfeldt, and **B.L. Herzog**, 1991, Water movement through an experimental soil liner: *Waste Management and Research*, V. 9., pp. 195-240.

**Leetaru, H.E.**, 1991, Analysis of pre-1960 logs can pinpoint pay in Illinois' Aux Vases, other zones, regions: *Oil and Gas Journal*, Feb. 25, 1991, pp. 50-52.

**Leighton, M.W.**, 1991, Introduction to interior cratonic basins: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 1-28.

**Leighton, M.W., and D.R. Kolata**, 1991, Chapter 35, Selected interior cratonic basins and their place in the scheme of global tectonics — a synthesis: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 729-797.

**Leighton, M.W., D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., 1991, *Interior Cratonic Basins*: American Association of Petroleum Geologists Memoir 51, Tulsa, OK, 819 p.

**Lizzio, A.A.**, and L.R. Radovic, 1991, Transient kinetics study of catalytic char gasification in carbon dioxide: *Industrial Engineering Chemical Research*, V. 30, p. 1735.

Mast, R.F., and **R.H. Howard**, 1991, Chapter 20, Oil and gas production and recovery estimates: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 295-298.

**Masters, J.M., W.T. Frankie, and R.E. Hughes**, 1991, Annual Review of 1990 Exploration, Mining, Minerals Processing, Coal; State Activities; Illinois: *Mining Engineering*, V. 43, N. 5, p. 498-499.

**Mikulic, D.G.**, 1990, The arthropod fossil record: biologic and taphonomic controls on its composition: *Short Courses in Paleontology: Arthropod Paleobiology*, Paleontological Society Special Publications No. 3, pp. 1-23.

**Mikulic, D.G.**, 1991, Chapter 6, Tippecanoe II subsequence: Silurian System through Lower Devonian Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 101-108.

Monaghan, G.W., and **A.K. Hansel**, 1990, Evidence for the Intra-Glenwood (Mackinaw) low-water phase of Lake Chicago: Canadian Journal of Earth Science, V. 27, pp. 1236-1241.

**Nelson, W.J.**, 1991, Chapter 16, Structural styles of the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 209-246.

**Nelson, W.J., C.B. Trask, R.J. Jacobson, H.H. Damberger,** A.D. Williamson, and D.A. Williams, 1991, Chapter 10, Absaroka sequence: Pennsylvanian and Permian Systems, *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 143-164.

Newman, W., **R.C. Berg**, P. Rosen, and H.D. Glass, 1990, Pleistocene stratigraphy of the Boston Harbor drumlins, Massachusetts, USA: *Quaternary Research*, V. 34, pp. 148-159.

**Norby, R.D.**, 1991, Chapter 13, Biostratigraphic zones in the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 179-196.

**Oltz, D.F.**, 1990, Getting more oil from reservoirs: *Northeast Oil World*, V. 10, pp. 20-23.

**Oltz, D.F.**, J.A. Rupp, B. Keith, and J. Beard, 1991, Chapter 28, Future hydrocarbon opportunities in the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 491-506.

**Panno, S.V.**, and W.B. Bourcier, 1990, Glaciation and saline/freshwater mixing as a possible cause of cave formation in the eastern midcontinent region of the United States: a conceptual model: *Geology*, V. 18, N. 8, pp. 769-772.

Radovic, L.R., H. Jiang, and **A.A. Lizzio**, A transient kinetics study of char gasification in carbon dioxide and oxygen: *Energy & Fuels* V. 5, p. 68.

Rhoads, B.L., and **M.V. Miller**, 1990, Impact of riverine wetlands construction and operation on stream channel stability: conceptual framework for geomorphic assessment: *Environmental Management*, V. 14, N. 6, pp. 799-807.

**Risatti, J.B., K.W. Miller, and S. Broeren**, 1990, Coal desulfurization studies: Inability of *Sulfolobus spp.* to oxidize sulfur compounds in coal: *Preprints,* American Chemical Society Fuel Chemistry Division, 200th National Meeting, Washington, DC, V. 35, N. 3, pp. 916-918

**Risatti, J.B.**, P. Ross, and L. Burnett, 1990, Amendment: Assessment of ecotoxicological hazard of Waukegan Harbor sediments: *Research Report Series*, Hazardous Waste Research and Information Center, Savoy, IL, HWRIC RR-052, 41 p.

**Rostam-Abadi, M., J.A. DeBarr, and W.T. Chen**, 1990, Combustion studies of coal-derived solid fuels by thermogravimetric analysis. III. Correlation between burnout temperature and carbon combustion efficiency: *Thermochimica Acta*, V. 166, pp. 351-356.

**Rostam-Abadi, M., D.L. Moran,** V.P. Roman, H. Yoon, and J.A. Withum, 1990, High surface area hydrated lime for $SO_2$ control: *Preprints of Papers*, American Chemical Society, Division of Fuels Chemistry, V. 25, N. 4, pp. 1418-1426.

**Roy, W.R.**, 1990, Review of the book *In Situ Immobilization of Heavy-Metal Contaminated Soils*: *Journal of Environmental Quality*, V. 19, p. 623.

**Roy, W.R., and R.A. Griffin**, 1991, An analytical model for in-situ extraction of organic vapors: *Journal of Hazardous Materials* V. 26, pp. 301-317.

**Sargent, M.L.**, 1991, Chapter 3, Sauk Sequence: Cambrian System through Lower Ordovician Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 75-86.

Schaetzel, R.J., and **L.R. Follmer**, 1990, Longevity of surface micromorphology created by tree uprooting with implications for mass wasting: *Geomorphology*, V. 3, pp. 113-123.

Schneider, A.F., and **A.K. Hansel**, 1990, Evidence for post-Two Creeks age of the type Calumet shoreline of glacial Lake Chicago: *in* A.F. Schneider and G.S. Fraser, eds., *Late Quaternary history of the Lake Michigan Basin*, Geological Society of America Special Paper 251, pp. 1-8.

**Seyler, B.**, and R.M. Cluff, 1991, Chapter 23, Petroleum traps in the Illinois Basin: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 361-402.

Shabica, C.W., F.A. Pranschke, and **M.J. Chrzastowski**, 1991, Survey of littoral drift sand deposits along the Illinois shore of Lake Michigan from Fort Sheridan to Evanston: *Illinois-Indiana Sea Grant Program,* Technical Report IL-IN-SG-R-91-3, Champaign, IL, 15 p.

Shabica, C.W., F.A. Pranschke, and **M.J. Chrzastowski**, 1991, Preliminary survey of littoral sand deposits along the Illinois shore of Lake Michigan from Waukegan to Evanston: *in* Folger, D.W., S.M. Colman, and P.W. Barnes, eds., *Third Annual Southern Lake Michigan Coastal Erosion Workshop*, U.S. Geological Survey Open-File Report 91-284, p. 46.

**Terpstra, P.D.**, 1991, Failure of riprap revetment along the Lake Michigan shoreline (photographs): *Journal of Coastal Research*, V. 77, N. 2, Frontispiece.

**Terpstra, P.D., and M. J. Chrzastowski**, 1991, Mathematical trends in the erosional evolution of a logarithmic-spiral bay on the Illinois shore: *in* Folger, D.W., S.M. Colman, and P.W. Barnes, eds., *Third Annual Southern Lake Michigan Coastal Erosion Workshop*, U.S. Geological Survey Open-File Report 91-284, pp. 47-48.

**Treworgy, J.D.**, 1991, Chapter 9, Kaskaskia Sequence: Mississippian Valmeyeran and Chesterian Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 125-142.

**Treworgy, J.D., and J.A. Devera**, 1991, Chapter 7, Kaskaskia Sequence overview: Middle Devonian Series through Chesterian Series: *in* **M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel,** eds., *Interior Cratonic Basins*, American Association of Petroleum Geologists Memoir 51, Tulsa, OK, pp. 109-112.

Wilson, J.R., P.D. Robinson, P.N. Wilson, L.W. Stanger, and **G.L. Salmon**, 1991, Gillulyite, $(Tl_2(As,Sb)_8S_{13}$, a new thallium sulfosalt from the Mercur gold deposit, Utah: *American Mineralogist*, V. 76, pp. 653-656.

Wood, K.V., C.C. Bonham, and **M.-I. M. Chou**, 1990, Characterization of geoporphyrins using plasma desorption mass spectrometry: *Energy and Fuels*, V. 4, N. 6, p. 747.

**Articles in Proceedings Volumes**

**Bauer, R.A., and P.B. DuMontelle**, 1991, Illinois Mine Subsidence Research Program: What have we learned in five years?: *Proceedings of the Illinois Mining Institute*, V. 89, p. 35-40.

**Bhagwat, S.B., L.A. Khan, and J.W. Baxter**, 1990, Factors determining the economic feasibility of reprocessing coal beneficiation wastes: *in* S. Joseph, R.G.L. McCready, and P.L. Wichlacz, eds., *Biohydrometallurgy 1989, International Symposium Proceedings*, Jackson Hole, WY, E.M.R. CANMET SP 89-10, pp. 753-761.

**Chrzastowski, M.J.**, 1991, A tribute to John C. Kraft and his contributions to coastal geology: *in* N.C. Kraus, K.J. Gingerich, and D.L. Kreibel, eds., *COASTAL SEDIMENTS '91, Proceedings of a Specialty Conference on Quantitative Approaches to Coastal Sediment Processes,* American Society of Civil Engineers, New York, NY, pp. 1265-1268.

**Dey, W.S., D.A. Keefer, and R.C. Berg**, 1991, Mapping the potential for aquifer recharge in Illinois: American Society of Agricultural Engineers, Paper 91-2110, St. Joseph, MI.

Ettensohn, F.R., S.F. Barnett, and **R.D. Norby**, 1990, Middle Devonian black shales in Kentucky: (preprint from) *Proceedings of the 1990 Eastern Oil Shale Symposium*, University of Kentucky, Institute for Mining and Minerals Research, Lexington, KY, 9 p.

**Follmer, L.R.**, 1990, Loess research in the Mississippi Valley region of the U.S.: *in* M. Zarate, ed., *Properties, chronology and paleoclimatic significance of loess*, International Symposium on Loess, University Mar del Plata, Argentina, pp. 112-115.

**Kelleher, III, J.T., D.J. Van Roosendaal, B.B. Mehnert, D.F. Brutcher, and R.A. Bauer**, 1991, Overburden deformation and hydrologic changes due to longwall coal mine subsidence in the Illinois Basin: *Proceedings of the Fourth International Symposium on Land Subsidence*, May 1991, Houston, TX, pp. 195-204.

**Krapac, I.G., K. Cartwright, S.V. Panno, B.R. Hensel,** K.H. Rehfeldt, and **B.L. Herzog**, 1990, Conductivity and transit time estimates of a soil liner: *in* R.M. Khanbilvardi and T.C. Gooch, eds., *Optimizing the resources for water management*, Proceedings of the 17th Annual National Conference, American Society of Civil Engineers, New York, NY, pp. 820-823.

**Krapac, I.G., K. Cartwright, S.V. Panno, B.R. Hensel,** K.H. Rehfeldt, and **B.L. Herzog**, 1990, Water movement through an experimental soil liner: *in* U.S. EPA, *Remedial Action, Treatment and Disposal of Hazardous Waste*, Proceedings of the 16th Annual Hazardous Waste Research Symposium, U.S. EPA Risk Reduction Laboratory, Cincinnati, OH, EPA/600/9-90 037, pp. 263-273.

**Krumm, R.J., E.D. McKay, C.C. Abert, M.M. McLean, M.H. Riggs, R.R. Pool, L.R. Smith, and S.L. Denhart**, 1991, Integrating GIS with surface and volume modeling to produce geologic maps: *Proceedings of the Eleventh Annual ARC/INFO User Conference, Volume II*, May 1991, Palm Springs, CA.

**Lizzio, A.A., and M. Rostam-Abadi**, 1991, Production of carbon molecular sieves from Illinois coals: an assessment: in *Proceedings of the Twentieth Biennial Conference on Carbon*, June, 1991, Santa Barbara, CA, p. 106.

**McKenna, D.P.**, 1990, Geologic mapping for protection of groundwater resources: in *Proceedings of the U.S. Geological Survey/U.S. Department of Agriculture workshop on models and data needs relating to the impact of agricultural practices on water quality*, U.S. Geological Survey Open File Report, pp. 99-100.

**Mehnert, B.B., D.J. Van Roosendaal, R.A. Bauer, and D.F. Brutcher**, 1990, Effects of longwall mine subsidence on overburden fracturing and hydrology in Illinois: *in* C.D. Elifrits, ed., *Proceedings of the National Symposium on Mine Subsidence — Prediction and Control*, Association of Engineering Geologists Annual Meeting, October 1990, Pittsburgh, PA, pp. 105-112.

**Oltz, D.F.**, 1990, Reservoir characterization in Illinois including deltaic sands: *Proceedings of the Symposium on Unstructured Deltaic Reservoirs*, Dallas, TX, January 28-29, 1991, U.S. Department of Energy.

**Panno, S.V., K. Cartwright, B.R. Hensel, I.G. Krapac,** K.H. Rehfeldt, and **B.L. Herzog**, 1990, Infiltration of water into a field-scale compacted soil liner: two years of monitoring: *in* Illinois Department of Energy and Natural Resources, *Proceedings of the Conference on Solid Waste Research*, Springfield, IL, pp. 8-9.

Radovic, L.R., **A.A. Lizzio,** and H. Jiang, 1991, Reactive surface area: an old but new concept in carbon gasification: *in* J. LaHaye and P. Ehrburger, eds., *Fundamental issues in control of carbon gasification reactivity*, Kluwer Academic Publishers, Dordrecht, Netherlands, p. 235.

**Stohr, C.J., and W.-J. Su**, 1991, Interpretation of landslides along the Ohio and Mississippi Rivers using medium-scale aerial photography and SLAR imagery: *Proceedings of the Eighth International Thematic Conference on Geologic Remote Sensing, Exploration, Engineering and the Environment*, Denver, CO, April 29 - May 2, 1991.

Tandarich, J.P., R.G. Darmody, and **L.R. Follmer**, 1990, Some interdisciplinary and international connections in the development of pedology: *International Society of Soil Science Symposium*, Japan.

**Taylor, G.D., R.R. Pool,** and M.M. Parrish, 1991, GIS applications for the coal mine permit review process in Illinois: in *Proceedings of the Eleventh Annual ARC/INFO Users Conference*, May, 1991, Palm Springs, California, Environmental Science Research Institute, Redlands, CA.

**Van Roosendaal, D.J., D.F. Brutcher, B.B. Mehnert, J.T. Kelleher, III, and R.A. Bauer**, 1990, Overburden deformation and hydrologic changes due to longwall mine subsidence in Illinois: *in* Y.P. Chugh, ed., *Proceedings of the 3rd Conference on Ground Control Problems in the Illinois Coal Basin*, Southern Illinois University, Carbondale, pp. 73-82.

**Yeko, J.D.**, 1990, Integrating a large database with other applications: CONQuEST—the user's interface: in *International Oracle User Week Proceedings*, Anaheim, CA, September 23-27, 1990, pp. 605-609.

**Other Publications**

**Cahill, R.A.**, 1991, Cesium-137 determination of sedimentation rates, organic carbon and trace metals distributions in the Grand Calumet River: included as Appendix A in report entitled *The Sanitary District of Hammond, Indiana, Grand Calumet River Sediment Study, Supplemental Addendum*, prepared by Howard, Needles, Tammen and Bergendoff, Chicago, IL, March 1991, under Job No. 13307-19-00, 356 p.

**Chrzastowski, M.J.**, 1990, Proposed rebuilding of Chicago's decaying lakefront structures: *The Helm, Happenings and Educational Activities Around Lake Michigan*, Illinois-Indiana Sea Grant Program newsletter, V. 6, N. 1, Spring/Summer 1990, p. 3.

**Curry, B.B.**, and A.J. Smith, 1991, Preliminary survey of ostracodes from Jamestown Quarry: *Quaternary deposits and landforms, confluence region of the Mississippi, Missouri and Illinois Rivers:* 38th Field Conference of the Midwest Friends of the Pleistocene, Open File Report, Department of Geology, University of Illinois at Urbana-Champaign, pp. 95-96.

**DuMontelle, P.B., R.A. Bauer, and B.A. Trent**, 1990, Program Assessment Report for 1989 for the Illinois Mine Subsidence Research Program: Submitted to the Illinois Coal Development Board, Springfield, IL, 25 p.

**DuMontelle, P.B., R.A. Bauer, and B.A. Trent**, 1990, Annual Report for Fiscal Year 1990 for the Illinois Mine Subsidence Research Program: Submitted to the Illinois Coal Development Board, Springfield, IL, 27 p.

**DuMontelle, P.B., R.A. Bauer, and B.A. Trent**, 1991, Program Implementation Plan for fiscal year 1992 for the Illinois Mine Subsidence Research Program: Submitted to the Illinois Coal Development Board, Springfield, IL, 27 p.

**Follmer, L.R.**, ed., 1991, INQUA/ISSS Paleopedology Commission Newsletter No. 7, 32 p. (printed by ISGS).

Hajic, E.R., **L.R. Follmer,** and W. H. Johnson, 1991, Outwash terraces and terrace problems: *Quaternary deposits and landforms, confluence region of the Mississippi, Missouri and Illinois Rivers:* 38th Field Conference of the Midwest Friends of the Pleistocene, Open File Report, Department of Geology, University of Illinois at Urbana-Champaign, p. 90.

Kluessendorf, J., and **D.G. Mikulic**, 1990, A teacher's guide to the Thornton Quarry: Handout for a field trip to the Thornton Quarry for teachers, sponsored by the Chicago Academy of Sciences.

Locke, W.W., and **N.P. Schnelder**, 1990, General geology and geomorphology of the Madison Range and Valley, southwest Montana: *in* R.D. Hall, ed., *Quaternary geology of the western Madison Range, Madison Valley, Tobacco Root Range and Jefferson Valley*, Guidebook for the annual field conference, Rocky Mountain Friends of the Pleistocene, pp. 1-23.

**Oltz, D.F.**, 1990, Research on improved and enhanced oil recovery through reservoir characterization: U.S. Department of Energy, Office of Scientific and Technical Information, DOE/BC/14250-2, 21 p.

**Panno, S.V.**, 1991, Groundwater: Where it comes from; where it goes: *Illinois Municipal Review*, June, pp. 27-29.

**Sargent, M.L.**, 1990, Isopach map of the New Albany Group in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L.**, and C. Roemmele, 1990, Isopach map of the Maquoketa Group in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent. M.L.**, 1990, Isopach map of the Everton Dolomite in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L.**, 1990, Isopach map of the St. Peter Sandstone in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L.**, 1990, Isopach map of the Ottawa Supergroup in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L.**, 1991, Lithofacies map of the Eau Claire/Bonneterre Formation in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L.**, 1991, Lithofacies map of the Ottawa Supergroup in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L.**, 1991, Map of the morphology on the Precambrian crystalline basement in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L., and Z. Lasemi**, 1991, Isopach map of the Lower and Middle Devonian Series in the Paducah 1° X 2° Quadrangle, Illinois, Kentucky, Missouri, and Indiana: U.S. Geological Survey CUSMAP Program, scale 1:250,000.

**Sargent, M.L., J.D. Treworgy, and S.T. Whitaker**, 1991, West-East cross section from the Ozark Dome, Missouri, across southern Illinois to the Rough Creek Graben, Kentucky,: U.S. Geological Survey CUSMAP Program, scale 1:250,000 horizontal, 1:4,800 vertical.

**Schnelder, N.P.**, 1990, Terrace geomorphology of the central Madison Valley: *in* R.D. Hall, ed., *Quaternary geology of the western Madison Range, Madison Valley, Tobacco Root Range and Jefferson Valley*, Guidebook for the annual field conference, Rocky Mountain Friends of the Pleistocene, pp. 24-53.

**Schnelder, N.P.**, and W.W. Locke, 1990, Four-dimensional segmentation of the Madison Range and Valley, southwest Montana: *in* R.D. Hall, ed., *Quaternary geology of the western Madison Range, Madison Valley, Tobacco Root Range and Jefferson Valley*, Guidebook for the annual field conference, Rocky Mountain Friends of the Pleistocene, pp. 59-81.

**Treworgy, C.G.**, 1990, A GIS database of mine maps aids land use planning and resource assessment: *Illinois GIS & Mapnotes*, V. 10, N. 1, pp. 19-21.

**Treworgy, J.D., S.T. Whitaker, and M.L. Sargent**, 1991, SW-NE cross section from southern Illinois to the southeastern flank of the Ozark Dome, Missouri: U.S. Geological Survey CUSMAP Program, horizontal scale 1:250,000, vertical scale 1:4,800.

**Whitaker, S.T., J.D. Treworgy, and M.L. Sargent**, 1991, NW-SE cross section from the Sparta Shelf, southwestern Illinois, to the Rough Creek Graben, western Kentucky: U.S. Geological Survey CUSMAP Program, horizontal scale 1:250,000, vertical scale 1:4,800.

Illinois Department of Energy and Natural Resources
STATE GEOLOGICAL SURVEY DIVISION

# RECOGNITION AND SERVICE

July 1990 to June 1991

## HONORS AND AWARDS

### Prizes, Medals, High Offices, and Other Honors

The poster session, "Multi-Level GIS Applications in Geologic Mapping," prepared by the members of the Geologic Mapping and Digital Cartography Section received a second place award in the "Most Analytical" category at the 1991 ARC/INFO Users Conference, Palm Springs, CA, May 1991.

**Chen-Lin Chou** was appointed an Adjunct Professor of the Graduate Faculty of Western Kentucky University for the period he is serving on a thesis advisory committee for a graduate student at the University.

**Charles Collinson and Dennis Kolata** were co-recipients of the 1990 award for Distinguished Achievement presented by the ISGS.

**Michael Chrzastowski** has been selected by the Executive Committee of Project 274 of the International Geological Correlation Project to be the United States' representative at the project's 1991 annual symposium to be held July 23-31, 1991 at Hainan Island, People's Republic of China.

**Beverly Herzog** was elected to be listed in the 17th edition of *Who's Who of American Women.*

**Richard Howard** received a citation from the Potential Gas Committee in October 1990 for his continuous service and loyal support.

**Hannes Leetaru** was named Outstanding New Staff Member by the ISGS at the annual Retirement and Recognition reception, October 23, 1990.

**Anthony Lizzio** and his co-authors Hong Jiang and Ljubisa R. Radovic received an award from Pergamon Press and the American Carbon Society for the Best Paper published in the journal *Carbon* in 1990. The award was presented at the Twentieth Biennial Conference on Carbon at Santa Barbara, CA, June 27, 1991.

The **Oil and Gas Section** and the **Publications, Graphics, and Photography Unit** received the ISGS Special Achievement award for their outstanding contributions to the ISGS and the people of Illinois.

**David Moran and Massoud Rostam-Abadi** were recognized at a special reception at the ISGS on March 19, 1991, for the acceptance of their high-surface-area hydrated lime invention for development and licensing by Research Corporation Technologies. The invention acceptance payment was awarded also.

## SCIENTIFIC AND EDUCATIONAL CONTRIBUTIONS

### Papers Presented at Scientific Meetings

**Richard Cahill** presented the paper, "Overview of the significance of radon in natural gas: an update," at the Conference on Gas Quality Measurements in Chicago, IL, July 16-17, 1990. At the Conference on Solid Waste Research in the Midwest held in Chicago, October 26-27, 1990, Mr. Cahill presented "An evaluation of leaf and grass composting with regard to pesticides and other toxic residues."

**Chen-Lin Chou** presented the paper, "Production of superclean coal by wet-grinding and selective flocculation," at the Illinois Coal Development Board Eighth Annual Contractors' Technical meeting, Urbana, IL, July 31-August 2, 1990. At the annual meeting of the Geochemical Society in Dallas, TX, October 29-November 1, 1990, Dr. Chou presented the poster session, "Formation of pyrite and organic sulfur in coal: a review." He presented "Distribution and forms of chlorine in Illinois Basin coals" at the annual meeting of the North-Central Section, Geological Society of America, April 18-19, 1991, in Toledo, OH.

**Michael Chrzastowski** participated in the 1990 Central Region Cluster Meeting with the Geologic Division of the U.S. Geological Survey. At the meeting, held in Baton Rouge, LA, September 8-11, 1990, Dr. Chrzastowski presented the paper, "Overview of the USGS/ISGS southern Lake Michigan coastal erosion study." At the annual meeting of the Quaternary Geology and Geomorphology Division of the

Geological Society of America in Dallas, TX, October 29-November 1, 1990, Dr. Chrzastowski presented "Geologic setting of the Olson tree site, Lake Michigan." He presented "Coastal evolution of the southern shore of Lake Michigan since late Wisconsinan time" at the Research Conference on Coastal Evolution, sponsored by the SEPM and Project 274 of the International Geological Correlation Program. As keynote speaker for a symposium honoring John C. Kraft, Dr. Chrzastowski presented "A tribute to John C. Kraft and his contributions to coastal geology." The symposium was held in conjunction with COASTAL SEDIMENTS '91, A Specialty Conference on Quantitative Approaches to Coastal Sediment Processes, sponsored by the American Society of Civil Engineers at Seattle, WA, June 25-27, 1991.

**Robert Cole** presented the poster session, "Preliminary paleogeographic reconstruction of the Illinois Basin during deposition of the Mississippian Aux Vases Formation: Implications for hydrocarbon recovery," at the annual meeting of the American Association of Petroleum Geologists in Dallas, TX, April 7-10, 1991.

**Dennis Coleman** presented the talk, "Identification of landfill gas using radiocarbon dating," at the 14th International Radiocarbon Dating Conference in Tucson, AZ, May 20-24, 1991. His co-author **Jack Liu** also attended the meetings.

**Brandon Curry** presented the paper, "Paleoenvironments and lithology of the Hopwood Farm Site, Montgomery County, Illinois," at the annual meeting of the North Central Section, Geological Society of America, Toledo, OH, April 18-19, 1991. During the 38th Field Conference of the Midwest Friends of the Pleistocene near St. Charles, MO, May 11, 1991, Mr. Curry presented a discussion of the significance of the ostracode fauna at the Jamestown Quarry, Stop 5 of the field trip.

**Heinz Damberger** presented the invited paper, "Peat-penecontemporaneous rivers in the Pennsylvanian of the Illinois Basin: The evolution of a concept and its economic significance," at the annual meeting of the Coal Division, Geological Society of America in Dallas, TX, October 29-November 1, 1990.

**Joe DeBarr** presented the paper, "Combustion characteristics of coal-char blend fuels," at the Eighth Annual Contractors' Technical meeting of the Illinois Coal Development Board, Urbana, July 31-August 2, 1990.

**William Dey** presented the papers, "Mapping the potential for recharge in Illinois" and "A survey of agricultural chemicals in rural private wells in Illinois," at the Summer Meeting of the Society of Agricultural Engineers at Albuquerque, NM, June 23-27, 1991.

**Henry Ehrlinger** presented the papers, "Column vs subaeration cells for the flotation of fine coal from plant waste" and "Particle size enlargement of fine coal of char using lignocellulosic residue from TVA's biomass program," at the Eighth Annual Contractors' Technical Meeting, sponsored by the Illinois Coal Development Board at Urbana, July 31-August 2, 1990.

**Anne Erdmann** presented the paper, "Assessing environmental risk in an urban environment," at the 33rd annual meeting of the Association of Engineering Geologists in Pittsburgh, PA, October 1-4, 1990.

**Wayne Frankie** presented the poster paper, "Geology and hydrocarbon potential of the Mississippian Big Lime in southeastern Kentucky," at the meeting of the Indiana-Kentucky Geological Society, Evansville, IN, March 26, 1991.

**Jonathan Goodwin** presented the paper, "Resources for teaching geology available from the Illinois State Geological Survey," at the annual meeting of the North Central Section, Geological Society of America, April 18-19, 1991, at Toledo, OH.

**Keith Hackley and Chao-Li (Jack) Liu** presented the poster session, "Effect of microbial methane formation on the carbon isotopic composition and radiocarbon age of dissolved inorganic carbon in groundwater," at the annual meeting of the Geochemical Society, Dallas, TX, October 29-November 1, 1990. At the 14th International Radiocarbon Conference in Tucson, AZ, May 20-24, 1991, Mr. Hackley presented the paper, "Radiocarbon dating of groundwater containing microbial methane."

**Richard Harvey** presented the paper, "Characterization of the organic sulfur in macerals and chars," at the Illinois Coal Development Board's Eighth Annual Contractors' Technical Meeting at Urbana, July 29-August 2, 1990.

**Bruce Hensel** presented the paper, "Moisture movement in an experimental soil liner," at the annual meeting of the Hydrogeology Division, Geological Society of America, in Dallas, TX, October 29 - November 1, 1990.

**Randall Hughes** presented the invited paper, "The nature detection, occurrence and origin of kaolinite/smectite," at the 27th annual meeting of the Clay Minerals Society at Columbia, MO, October 6-11. He also participated in a field trip to the Missouri fireclay and flint clay districts in conjunction with the meeting. At the joint annual meting of the American Society of Agronomy, Crop Science Society of America and Soil Science Society of America in San Antonio, TX, October 21-26, 1990, Dr. Hughes presented "Qualitative and quantitative analysis of clay minerals in soils."

**Jay Kelleher** presented the talk, "Overburden deformation and hydrologic changes due to longwall coal mine subsidence in the Illinois coal basin," at the Fourth International Symposium on Land Subsidence, Houston, TX, May 13-17, 1991.

**Dennis Kolata** presented the paper, "Proterozoic crustal domain boundary at the southern end of the Illinois Basin," at the annual meeting of the North Central Section, Geological Society of America, Toledo, OH, April 18-19, 1991.

**Robert Krumm** presented the paper, "Integrating GIS with surface and volume modeling to produce geologic maps," at the Eleventh Annual ARC/INFO Users Conference, Palm Springs, CA, May 22, 1991. Rob and **Sally Denhart** co-presented the poster session, "Multi-level GIS applications in geologic mapping," at the same conference, May 20, 1991.

**Carl Kruse** participated in the Gordon Research Conference in New Hampton, NH, in July 1990, where he presented the poster session, "Innovative uses of a unique sulfur isotope sample, IBC-107, from the Illinois Basin Coal Sample Program." Dr. Kruse also presented the papers, "Production of premium liquids by mild gasification" and "The Illinois Basin coal sample program," at the Illinois Coal Development Board's Eighth Annual Contractors' Meeting, July 31-August 2, 1990, at Urbana.

**Hannes Leetaru, Donald Oltz, Beverly Seyler, and Stephen Whitaker** each presented portions of the invited paper "An integrated approach to reservoir characterization in the Illinois Basin," at the First Annual Archie Conference in Houston, TX, October 22-25, 1990.

**Anthony Lizzio** presented the paper, "A temperature-programmed desorption and transient kinetics study of noncatalytic char gasification," at the annual meeting of the American Institute of Chemical Engineers, Chicago, November 1990. At the Twentieth Biennial Conference on Carbon in Santa Barbara, CA, in June 1991, he presented the paper, "Production of carbon molecular sieves from Illinois coals: an assessment."

**Brenda Mehnert** presented the paper, "Effects of longwall mine subsidence on overburden fracturing and hydrology in Illinois," at the symposium on *Mine Subsidence — Prediction and Control* at the annual meeting of the Association of Engineering Geologists in Pittsburgh, PA, October 2, 1990.

**Donald Mikulic** presented the poster session, "Temporal, ecological and environmental trends in Phanerozoic soft-bodied fossil Lagerstätten" at the annual meeting of the Paleontological Society in Dallas, TX, October 29-November 1, 1990. At a pre-meeting short course on *Arthropod Paleobiology*, Dr. Mikulic presented, "The arthropod fossil record: biological and taphonomic controls on its composition." At the annual meeting of the North Central Section, Geological Society of America, Dr. Mikulic presented, "Silurian reef development along the western edge of the Michigan Basin."

**Duane Moore** presented the poster session, "The clay mineralogy of two Mississippian sandstone reservoirs in the Illinois Basin," at the 27th annual meeting of the Clay Minerals Society at the University of Missouri-Columbia, October 6-11, 1990. Also at that meeting, Drs. Moore and **Hughes** co-presented the poster session, "Berthierine pipestones of Native Americans in the Mid-Continent." At the annual meeting of the American Association of Petroleum Geologists in Dallas, TX, April 7-10, 1991, Dr. Moore

presented, "Varieties of chlorites and illites and porosity in Mississippian sandstone reservoirs in the Illinois Basin."

**David Moran** presented the paper, "Evaluation of high-surface-area hydrated lime for $SO_2$ control," at the Illinois Coal Development Board's Eighth Annual Contractors' Technical Meeting at Urbana, July 31-August 2, 1990.

**Donald Oltz** presented the paper, "Reservoir characterization in Illinois including deltaic sands," at the *Symposium on Unstructured Deltaic Reservoirs*, sponsored by the U.S. Department of Energy in Dallas, TX, January 29-30, 1991.

**Samuel Panno** presented the paper, "Infiltration of water into a field-scale compacted soil liner," at the conference on *Solid Waste Research in the Midwest*, sponsored by the Illinois Department of Energy and Natural Resources at Chicago, October 26-27, 1990. At the 27th Annual Meeting of the Clay Minerals Society at the University of Missouri-Columbia, October 6-11, 1990, he presented the paper, "Alteration of clay minerals of the Davis Formation, southeast Missouri."

**David Rapp** presented the paper, "A method for improving sulfur capture using coal/sorbent pellets," at the Illinois Coal Development Board's Eighth Annual Contractors' Technical Meeting at Urbana, July 31-August 2, 1990.

**Bruno Risatti** presented the paper, "Coal desulfurization studies: inability of *Sulfolobus spp.* to oxidize sulfur compounds in coal," at the 200th national meeting of the American Chemical Society in Washington, DC, August 26-31, 1990. He also participated in the Gordon Research Conference on Organic Chemistry at Holderness, NH during August. He was a co-presenter of the paper, "Microbial suppression of pyrite from Illinois coals: new reagents and scale-up," at the Illinois Coal Development Board's Eighth Annual Contractors' Technical Meeting in Urbana, July 31-August 2, 1990.

**Massoud Rostam-Abadi** presented the paper, "High-surface-area hydrated lime for $SO_2$ control," at the 200th national meeting of the American Chemical Society in Washington, DC, August 26-31, 1990.

**William Roy** presented the paper, "Geochemical modelling and transformation of two injection-well wastes: long-term laboratory studies," at the spring meeting of the American Geophysical Union, Baltimore, MD, May 28-June 1, 1991.

**Nicholas Schneider** presented the poster session, "Resource recovery and wetland preservation: implications for impact from a sand and gravel operation in northeastern Illinois," at the annual meeting of the North Central Section, Geological Society of America, Toledo, OH, April 18-19, 1991.

**Beverly Seyler** presented the paper, "Aux Vases Sandstone reservoir, Zeigler Field, Franklin County, Illinois," at the annual meeting of the Eastern Section, American Association of Petroleum Geologists in London, Ontario, Canada, September 10-14, 1990. She also attended a short course, "Diagenesis, methods and applications," at this meeting. Ms. Seyler also attended the 27th annual meeting of the Clay Minerals Society at the University of Missouri-Columbia, October 9-10, 1990.

**Paul Terpstra** presented the talk, "Monitoring of 1989-1990 beach and nearshore geomorphic changes at North Point Marina, Winthrop Harbor, Illinois," at the annual meeting, North Central Section, Geological Society of America, Toledo, OH, April 18-19, 1991. At the 34th Conference on Great Lakes Research in Buffalo, NY, June 2-6, 1991, Mr. Terpstra presented the talk, "Summary of lake bottom changes at North Point Marina vicinity between 1988 and 1990."

**Brian Trask and Myrna Killey** presented the paper, "Expert stratigraphic interpretation of water well logs and sample sets provides valuable data for environmental projects," at the annual meeting of the Association of Engineering Geologists, Pittsburgh, PA, October 1-4, 1990. While there, they participated in a walking geological tour of Pittsburgh and the field trip, "Engineering geology, land development and highways in Allegheny County, PA."

**Dan van Roosendaal** presented the paper, "Overburden deformation and hydrologic changes due to longwall mine subsidence in Illinois," at the Third Conference on Ground Control Problems in the Illinois Coal Basin at Mt. Vernon, August 8, 1990.

**Pius Weibel** presented the paper, "Case history of site characterization of bedrock stratigraphy at the Geff Alternative Site for low-level radioactive waste disposal, Wayne County, Illinois," at the annual meeting of the Geological Society of America, Dallas, TX, October 29-November 1, 1990. He also participated in a pre-meeting short course, "Contaminant hydrogeology: practical monitoring, protection and cleanup," and a post-meeting field trip, "Hydrogeology of the Blaine gypsum-dolomite karst aquifer, southwestern Oklahoma." At the annual meeting of the North Central Section of GSA, in Toledo, OH, April 18-19, 1991, he presented his paper, "Cyclothem revival! (Sequence stratigraphy of Upper Pennsylvanian strata, east-central Illinois)." Following this meeting, he participated in the field trip, "Middle Devonian silica shale of northwest Ohio.

**John Yeko** presented the paper, "Integrating a large database with other applications: CONQuEST—the user's interface," at the International Oracle User Week in Anaheim, CA, September 23-27, 1991.

### Scientific Workshops/Training Courses Taught or Attended

**Robert Bauer** presented a talk on state geological surveys' responsibilities before and after an earthquake event for an earthquake preparedness workshop sponsored by the Central United States Earthquake Consortium (CUSEC) in Bloomington, IL, June 20, 1991. Earlier, he participated in U.S. Geological Survey-sponsored workshops on Coordinated Earthquake Response and on the Role of State Geological Surveys in Post-Earthquake Investigations held in St. Louis, MO on November 8, 1990 and April 2-3, 1991, respectively. He also participated in the two-day workshop at the ISGS, April 4-5, 1991, to begin the development of the ISGS's earthquake event response plan.

**Robert Bauer and Nicholas Schneider** led a special field trip, September 17-20, 1990, to acquaint new staff members of the Environmental Assessment project with the geology and geomorphic features of Illinois.

**James Baxter** participated in a mineral assessment workshop for the Shawnee National Forest sponsored by the U.S. Geological Survey, October 9-10, 1990. He also participated in the workshop on the Midcontinent Strategic and Critical Minerals project, May 28-30, 1991. He and several other staff members, including **James Eidel**, participated in a workshop at the ISGS, April 24-May 3, 1991, to review the progress on the Paducah CUSMAP project and define mineral assessment models.

**Scott Beaty, Joan Crockett, Ilham Demir, Joe Fagan, Wayne Frankie, John Grube, Dennis Haggerty, Hannes Leetaru, Richard Rice, and Beverly Seyler** participated in the workshop, "Formation evaluation of shaly sand reservoirs," taught by George Asquith at Grayville, IL, March 22, 1991.

**Scott Beaty and Beverly Seyler** attended the workshop, "Mixed Carbonate-Siliciclastic Sequences" and a short course on cathodoluminescence microscopy in connection with the annual meeting of the American Association of Petroleum Geologists, April 6-7, 1991. Mr. Beaty, Ms. Seyler and **Robert Cole, Joan Crockett, Ilham Demir, Wayne Frankie, John Grube, Richard Howard, Bryan Huff, Hannes Leetaru, Kenneth McGee, Donald Oltz, and Richard Rice** participated in a 3-day field workshop in southern Illinois to study outcrops of the Mississippian Cypress and Aux Vases Formations, November 13-15, 1990.

**Richard Berg** participated in a workshop on hydrogeologic mapping methodologies, sponsored by the USEPA at Boulder, CO, July 23-25, 1990. At the four Groundwater Protection Education workshops, held April 10 at Rockford, April 11 at Aurora, April 16 at Peoria, and April 18, 1991 at Mt. Vernon, he presented "Status of groundwater protection programs at the ISGS and ISWS." At the workshop entitled, "A Primer on the Essentials of Groundwater Protection," sponsored by the McHenry County Board of Health and McHenry County College at Crystal Lake, May 7, 1991, Dr. Berg presented "Geologic mapping for groundwater protection," and **Subhash Bhagwat** reviewed the results of his study of the benefits and costs of geologic mapping.

**Subhash Bhagwat** presented a talk on the results of the study of the benefits and costs of geologic mapping and their State-wide applicability at the workshop, "GIS Mapping Projects to Support Solid Waste Facility Siting," in Champaign on May 8, 1991.

**Richard Cahill** participated in the 16th Annual Midwest Environmental Chemistry Workshop at the University of Illinois, October 15-16, 1990.

**Melissa Chou and Sheng-Fu Chou** attended the 42nd Annual Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, held in Chicago, March 3-8, 1991. While there Melissa participated in two workshops, "Principles of quality assurance of chemical measurements" and "Basic statistics for analytical chemists." Later, Melissa attended a short course, "Operation and maintenance of the LECO SC-32 sulfur analyzer," offered by the LECO Corporation on June 3-5, 1991.

**Michael Chrzastowski** participated in the short course, "Coastal Land Loss," held in Houston and Galveston, TX, Oct. 27-28, 1990, in connection with the annual meeting of the Geological Society of America. In Seattle, WA, June 24, 1991, he participated in a short course, "Cross-Shore Sediment Transport," sponsored by the American Society of Civil Engineers. He also participated in the U.S. Geological Survey's Third Annual Southern Lake Michigan Coastal Erosion Workshop held at the USGS Center for Coastal Geology at St. Petersburg, FL, February 5-6, 1991.

**Gayla Coats** participated in a training course, "Cartographic Production," taught by Environmental Systems Research Institute at Redlands, CA, March 20-21, 1991.

**Dennis Coleman** presented the invited lecture, "The geochemistry of natural gas and its application," at the Continuing Engineering Education Council Advanced Symposium on Underground Storage of Natural Gas, held in Salt Lake City, UT, May 13-17, 1991.

**Gary Dreher** participated in a workshop on the MINTEQ software system sponsored by the USEPA at Athens, GA, August 21-23, 1990.

**James Eidel** was one of the authors and presenters of a short course, "Sediment-hosted ore deposits and basin analysis," May 23-26, 1991, at Toronto, Ontario, Canada.

**Anne Erdmann** participated in an in-house short course on Illinois soils and groundwater geochemistry taught by Leon Follmer and William Roy, July 16-17, 1990. She also participated in two short courses offered by the National Water Well Association at Columbus, OH—"Principles of Groundwater Hydrology," December 3-5, 1990, and "Introduction to Groundwater Geochemistry," March 26-28, 1991. On April 22, 1991, Ms. Erdmann, **Brenda Mehnert, and Paula Rimmer** attended the seminar, "High-impact communication skills for women," presented by Career Track in Urbana.

**Leon Follmer** presented a lecture on the response of soils to global climate change at the workshop on Global Climate Change, sponsored by the Commission on Global Change of the International Union for Quaternary Research (INQUA), in Marseille, France, September 3-7, 1990. He presented the paper, "Loess research in the Mississippi Valley region of the United States," and participated in the post-conference field trip at the International Symposium on Loess, sponsored by the INQUA Commission on Loess, at the University Mar del Plata, Argentina, November 25-December 1, 1990. During the spring, he attended the annual field conference of the Midwest Friends of the Pleistocene at St. Charles, MO, May 10-12, 1991, and the annual meeting of the North Central Section, Geological Society of America at Toledo, OH, April 18-19. He reviewed ISGS research activities for the Soil Conservation Service Workshop in Champaign, March 5, 1991.

**Wayne Frankie and Dennis Haggerty** participated in the short course, "Carbonate reservoirs—their origin, geometry and characteristics," taught by R. Michael Lloyd at Grayville, IL, April 18, 1991.

**Robert Frost** attended the 39th Annual Denver X-ray Conference in Steamboat Springs, CO, July 30 - August 3, 1990, where he participated in two days of workshops on specimen preparation and other aspects of X-ray fluorescence analysis.

**David L. Gross** served as one of four organizers of a conference entitled, "Assessing state technology programs: from the eighties into the nineties," held in Chicago in October, 1990. The conference brought together the directors of several state science and technology development/incentive programs to discuss the various methods used to evaluate their programs. **Jonathan Goodwin** represented the ISGS at the conference.

**Dennis Haggerty** participated in a short course on horizontal directional drilling at Halliburton Services in Duncan, OK, February 11, 1991. While there Mr. Haggerty and other members of the Oil and Gas Section presented to the Halliburton's acidizing group, "Effect of MCA on the Aux Vases Sandstone."

**Ardith Hansel** led a field conference to northeastern Illinois, June 25-26, 1991, for four of her colleagues from the Geologic Mapping and Digital Cartography Section to acquaint them with Quaternary units they will be mapping in Lake and Will Counties.

**Beverly Herzog** participated in the symposium , "Coping with uncertainty in the remediation and monitoring of contaminated groundwater," at the Beckman Institute in Urbana, October 24, 1990. The symposium was sponsored by the University and the Construction Engineering Research Laboratory of the U.S. Army Corps of Engineers.

**Bryan Huff** participated in the short course, "Development Geology," presented by Bob Sneider and Richard Harris, November 6-9, 1990 at Dallas, TX. He also attended a seminar, "Horizontal Hole Completions," offered by Halliburton Services at Grayville, IL, February 12, 1991.

**Donald Keefer** attended the short course, "Theory and application of monitoring, sampling and remediation in the vadose zone," offered by the National Water Well Association at Las Vegas, NV, November 6-8, 1990, and the workshop, "Characterization of transport phenomena in the vadose zone," offered by the American Geophysical Union and the Soil Science Society of America at Tucson AZ, April 2-5, 1991.

**Ivan Krapac** participated in the workshop, "Design and construction of RCRA/CERCLA final covers," sponsored by the USEPA at Chicago, August 14-15, 1990, and the short course, "Clayey barriers for mitigation of contaminant impact," taught at the Geotechnical research Centre, Department of Civil Engineering, University of Western Ontario, Waterloo, Canada.

**Robert Krumm, Donald McKay, Melissa McLean, Matthew Riggs, Subhash Bhagwat**, and staff members from the ENR Office of Solid Waste Reduction and Recycling and the Office of Research and Planning made presentations at a workshop for county government officials on applications of GIS to siting waste disposal facilities. Included in the workshop were tours of the GIS facility and a demonstration of GIS applications.

**Hannes Leetaru** offered a one-day, in-house training session on the use of the Zycor® mapping software package, and prepared a cookbook manual for staff wishing to approach some standard analytical problems with the GeoQuest® system.

**Anthony Lizzio** participated in a workshop, "Surface area analysis," at the Pittsburgh Conference held in Chicago in November 1990.

**John Lytle** was a discussion leader at the workshop, "Model sulfur compounds for coal cleaning research," held at the Center for Research on Sulfur in Coal, Carterville, IL, November 28, 1990.

**Dennis McKenna** participated in a workshop, "Methods for assessing the sensitivity of aquifers to pesticide contamination," sponsored by the USEPA at Boulder, CO, July 23-25, 1990. He also attended a management training seminar at Urbana, April 15-16, 1991.

**Melissa McLean** participated in a seminar on Geographic Information Systems at the Center for Governmental Studies, Northern Illinois University, DeKalb, August 9, 1990.

**Brenda Mehnert** attended a special seminar, "Soil pinning techniques, with demonstration," at the University of Illinois, Urbana, Champaign, November 15, 1990, through special arrangements of the Illinois Society of Professional Engineers and the American Society of Civil Engineers.

**Michael Miller** participated in a wetland delineation course for state delineation trainers, September 10-14, 1990 at Zion, IL. He also participated in a workshop, "Soil-Wetland Relationships," that included a field tour of the West Chicago Prairie, September 27-28, 1990, at Carol Stream, IL. Dr. Miller attended the workshop, "Wetland Soils and Hydrology," at Charleston, SC, November 29-December 2, 1990.

**Philip Reed** participated in a seminar on in-situ pH, Eh, conductivity and hydraulic conductivity measurements, sponsored by the USEPA and the U.S. Geological Survey, February 21, 1991.

**William Roy** presented a lecture, "Fate and transport of contaminants in gasoline," for the staff of the Environmental Assessment Section, July 17, 1990.

**Nicholas Schneider** participated in the short course, "Managing the environmental impacts of highway projects," offered by the College of Engineering, University of Wisconsin-Madison, November 28-30, 1990.

**Edward Smith** participated in the short course, "Geologic modelling of depositional environments," offered by the National Water Well Association at Charleston, SC, September 3-6, 1991.

**Wen-June Su** participated in a short course on application of microcomputers to rock slope stability analysis in conjunction with the annual meeting of the Association of Engineering Geologists at Pittsburgh, PA, October 1-5, 1990. At the annual meeting of the Engineering Geology Division, Geological Society of America, Dallas, TX, October 29-November 1, 1990, Mr. Su attended the short course, "Site selection for critical facilities—the earth science perspective." In Denver, CO, November 7-13, 1990, Mr. Su took an intensive training course in the use of the "Geo/SQL" software. The training course and the software were a part of a University Program Grant, provided by Generation 5 Technology of Denver and Autodesk, Inc. of Sausalito, CA, in support of Mr. Su's study of possible earth-induced landslides in southern Illinois.

**Billy Trent** participated in a one-day seminar, "How to write, design and edit newsletters," in Urbana, August 30, 1990.

**Colin Treworgy and Pius Weibel** participated in a workshop, "Predictive Stratigraphic Analysis," at Lawrence, KS, June 24-26, 1991, offered by the U.S. Geological Survey. The workshop was intended to help initiate a new research project on the Carboniferous geology of North America.

### Participation in Scientific Conferences and Field Trips

**Richard Berg** spoke on waste disposal siting issues at a meeting of the Illinois Groundwater Association at Starved Rock State Park Lodge, October 11, 1990. On March 24, 1991, he presented the keynote address, "Geologic and hydrologic factors for siting and site characterization of waste disposal facilities," at the annual meeting of the Northeastern Section of the Association of Engineering Geologists at Waltham, MA, March 24, 1991.

**Phyllis Bannon and Anne Erdmann** attended a program, "Northeastern Illinois: Regional Environmental Issues of the 21st Century," presented by the Illinois Association of Environmental Professionals in Chicago, January 23, 1991.

**Michael Barnhardt, Leon Follmer, Ardith Hansel, John Kempton, Dennis McKenna, Edward Smith, and Barbara Stiff** participated in the annual field conference of the Midwest Friends of the Pleistocene at St. Charles, MO, May 10-12, 1991.

**Robert Bauer and Brenda Mehnert** participated in the 3rd Conference on Ground Control Problems in the Illinois Coal Basin at Mt. Vernon, IL, August 8-10, 1990. Mr. Bauer also participated in the annual meeting of the Association of Engineering Geologists at Pittsburgh, PA, October 1-4, 1990.

**Scott Beaty** attended various meetings of the Illinois Geological Society during the year. He also participated in the annual meetings of the Clay Minerals Society in Columbia, MO, October 9-11, 1990 and the American Association of Petroleum Geologists in Dallas, TX, April 6-10, 1991. On February 5-7, 1991, he joined other staff of the Oil and Gas Section in touring the research facilities of the Halliburton well service company in Duncan, OK. He also participated in the field trip to visit Cypress Formation and Aux Vases Sandstone outcrops in southern Illinois, November 13-16, 1990.

**Subhash Bhagwat and Henry Ehrlinger** participated in the annual meeting of the Society for Mining, Metallurgy and Exploration (SME) in Denver, CO, February 23-28, 1991. At that meeting, Hank chaired meetings of the executive committee and the membership of the Industrial Minerals Division of SME.

Mr. Ehrlinger also participated in a meeting of the Board of Directors of SME at Reno, NV, in September 1990.

**Ross Brower and Phillp Reed** developed and presented an exhibit on groundwater resource information available from the Illinois State Geological Survey at the Illinois Specialty Growers Association and Irrigation Trade Show, January 22-24, 1991, Springfield; the Illinois Water Exposition, February 22-26, 1991, Springfield; the Illinois Groundwater Association meeting, March 28, 1991, Bloomington; and the Upper Midwest Water Well Exposition, April 8-9, 1991, La Crosse, WI.

**Richard Cahill** attended the 34th Conference on Great Lakes Research of the International Association for Great Lakes Research in Buffalo, NY, June 2-6, 1991.

**Keros Cartwright** presented the invited paper, "Construction and performance of a long-term earthen liner experiment," at the annual meeting of the American Society of Civil Engineers, November 5-8, 1990, San Francisco, CA. He also participated in the annual meeting of the Hydrogeology Division of the Geological Society of America in Dallas, TX, October 29-November 1, 1990, and the 16th annual Hazardous Waste Research Symposium sponsored by the U.S. EPA Risk Reduction Engineering Laboratory at Cincinnati, OH, April 9-11, 1991.

**Chen-Lin Chou** participated in the 98th annual meeting of the Illinois Mining Institute at Mt. Vernon, IL, September 22-23, 1990. He also participated in the field trip, "Coal geology of the western region of the interior coal province in parts of Kansas, Missouri and Oklahoma," sponsored by the Coal Geology Division of the Geological Society of America, October 25-28, 1990.

**Melissa Chou, Heinz Damberger, Ilham Demir, Keith Hackley, Lawrence Kohlenberger, John Lytle, and Massoud Rostam-Abadi** participated in the Eighth Annual Contractors' Technical Meeting of the Illinois Coal Development Board in Urbana, July 31-August 2, 1990.

**Michael Chrzastowski** participated in the annual meeting of the North Central Section, Geological Society of America, Toledo, OH, April 18-19, 1991, and the 34th Conference on Great Lakes Research of the International Association for Great Lakes Research, at Buffalo, NY, June 2-6, 1991. In conjunction with COASTAL SEDIMENTS '91, Dr. Chrzastowski participated in a field trip on "Depositional History of the Washington Coast."

**Joan Crockett** coordinated the development and presentation of the exhibit, "Improved and Enhanced Oil Recovery Through Reservoir Characterization," at the annual meeting of the American Association of Petroleum Geologists in Dallas, TX, April 7-10, 1991. The exhibit also was presented at the annual meeting of the Illinois Oil and Gas Association, March 7-8, 1991 in Evansville, IN. These exhibit presentations help to inform oil and gas industry leaders about our research and service programs. Others who participated in the Illinois Oil and Gas Association meetings in Evansville included **Wayne Frankie, Hannes Leetaru, Donald Oltz, Richard Rice, and Stephen Whitaker.**

**Brandon Curry** participated in the annual meeting of the Archaeological Geology Division of the Geological Society of America at Dallas, TX, October 29-November 1, 1990. In connection with that meeting he participated in the field trip, "Archaeology of the Upper Trinity River Valley." In connection with the annual meeting of the North Central Section of GSA, Mr. Curry participated in the field trip, "The Kelleys Island Glacial Grooves, Subglacial Erosion Features on Marblehead Peninsula, Carbonate Petrology and Associated Paleontology," on Saturday April 20, 1991, near Toledo, OH.

**Heinz Damberger** organized and participated in the annual meeting of the Illinois Mining Institute held at Mt. Vernon, IL, in September 1990. Other ISGS staff members who attended the meeting included **Robert Bauer, James Eidel, Wayne Frankie, and Richard Harvey**

**Joe DeBarr** attended the Seventh Annual International Pittsburgh Coal Conference at Pittsburgh, PA, September 10-14, 1990.

**Ilham Demir** participated in the annual meeting of the Society of Organic Petrology in Calgary, Alberta, Canada, September 9-14, 1990. As a part of the meeting, he took participated in the field trip to the

Drumheller coal field. Dr. Demir also joined other staff of the Oil and Gas Section in a tour of the laboratories and discussion of Illinois oil recovery problems at the Halliburton Services Company in Duncan, OK, February 5-7, 1991.

**William Dey, Anne Graese, Beverly Herzog, Donald Keefer, and Edward Mehnert** participated in meetings of the Illinois Groundwater Association during the year at Starved Rock State Park Lodge, October 11, 1990, and Bloomington, March 28, 1991. Mr. Dey and Mr. Mehnert also participated in the Midwest Groundwater Conference at Lincoln, NE, November 5, 1990. Mr. Dey attended a meeting on Livestock Waste Management at Champaign, March 19, 1991.

**Gary Dreher, Randall Hughes, and Duane Moore** attended the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, March 3-7, 1991 at Chicago.

**James Eldel** attended the scientific sessions at the annual Vincent McKelvey Forum, sponsored by the U.S. Geological Survey at Reno, NV, February 11-14, 1991. Immediately following the Forum, he attended a meeting of the Board of Directors of the Society of Exploration Geologists Foundation at Reno on Feb. 15.

**Leon Follmer** collaborated with Professors Bigarelli and Infanti of the University of Santa Catarina, Florianopolis, Italy, and Professors Coltrinari and Neto of the University of São Paulo in studies of soil-landscape evolution in Brazil, December 12-19, 1990. With Professor Robert Hall of the Indiana University-Purdue University geology department, he collaborated in examining paleosols in Indiana, November 9-10, 1991.

**Wayne Frankle** participated in the 1990 Eastern Oil Shale Symposium, Lexington, KY, November 6-8, 1990; a monthly meeting of the Illinois Geological Society in Olney on January 23, 1991; and the annual meeting of the Kentucky Oil and Gas Association in Owensboro, KY, June 5-7, 1991. On August 24, 1990 and January 17, 1991, he participated in meetings of the Principal Investigators (PIs) of the Illinois Basin Consortium/Gas Research Institute project on the New Albany Shale. A third meeting of the PIs was held in Lexington, KY, November 7, 1990.

**Jonathan Goodwin** mounted an exhibit, "Earth Science Teaching Resources Available from the ISGS," at the annual meeting of the North-Central Section, Geological Society of America, April 18-19, 1991, at Toledo, OH. At the annual meeting of the Geological Society of America in Dallas, TX, October 29-November 1, 1990, he and **Suzanne Muckensturm** installed an exhibit on ISGS research and service programs and assisted in the installation of the exhibit of the Association of American State Geologists.

**David L. Gross**, in his capacity as Executive Director of the Governor's Science Advisory Committee, participated in the Illinois Institute of Technology Centennial Conference on Science and Technology in Chicago in September, 1990; the annual meeting of the Geological Society of America in Dallas, TX, October 29-November 1, 1990, where he participated in a field trip to the proposed future site of the Superconducting Super Collider; and the annual meeting of the American Association for the Advancement of Science in Washington, DC, in February 1991.

**John Grube** participated in a meeting of the Society of Petroleum Engineers at Grayville, IL, October 18, 1990, where the $CO_2$ "Huff 'n Puff" project at Big Sinking Field, PA, was reviewed. In March 1991, he and several other Oil and Gas Section staff members visited Marathon Oil Company's offices in Bridgeport, IL, to discuss the reservoir characterization project for the Lawrenceville Field.

**Ardith Hansel** participated in the annual meeting of the North Central Section of the Geological Society of America at Toledo, OH, April 18-19, 1991. While there, she went on a field excursion to the Kelley's Island glacial grooves near Toledo. Earlier, she participated in the Mid-Norden Project Annual Field Trip, sponsored by the Norwegian, Swedish and Finnish Geological Surveys, in central Finland, September 3-7, 1990. Dr. Hansel also attended the Third International Drumlin symposium field trip entitled "Glacial Heritage of Northern Finland," June 27-July 2, 1990.

**Richard Harvey** chaired two meetings of the Subcommittee on Classification of Coal of the American Society for Testing and Materialsem—in San Antonio, TX, October 28-31, 1990, and Charlotte, NC, May 19-22, 1991. Dr. Harvey also participated in a meeting of the Council of the Society of Organic Petrology at Dallas, TX, April 6, 1991. In Chicago, on March 6, 1991, he attended the annual Pittsburgh Coal

Conference. Dr. Harvey and **Michael Sargent** participated in the annual Tri-State Field Conference held at Iowa City, IA, October 5-6, 1990. The field conference examined the stratigraphy and paleoenvironments of the Mississippian in Keokuk and Washington Counties, southeast Iowa."

**Bryan Huff** attended several of the monthly meetings of the Illinois Geological Society held at Olney, Mt. Vernon, and Grayville during the year. At the February 26, 1991 meeting in Mt. Vernon, Mr. Huff presented an illustrated talk on his visit to the oil "mine" in the Siggins Field. Earlier, he presented the same talk at the Technical Advisory Committee/Petroleum Advisory Committee meeting in Mt. Vernon, December 13, 1990.

**Randall Hughes and Duane Moore** presented a poster exhibit, "Clay minerals in Aux Vases and Cypress reservoirs," at a meeting of the Illinois Oil and Gas Producers Association at Mt. Vernon.

**Donald Keefer** presented a talk, "Groundwater protection efforts under the Illinois Groundwater Protection Act," at the Illinois Geological Society's meeting in Olney, IL, September 27, 1990. He also attended the annual meeting of the Soil Science Society of America at San Antonio, TX, October 21-26, 1990.

**John Kempton** presented the talk, "Hydrogeology of the glacial deposits of the Bloomington-Normal area," at the spring meeting of the Illinois Groundwater Association, March 28, 1991, at Bloomington.

**Latif Khan** has been a member of the organizing committee and the program advisory committee of the National Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation since 1987.

**Myrna Killey** attended the specialty conference, "Water quality management of landfills," sponsored by the Water Pollution Control Federation at Chicago, IL, July 15-18, 1990. Ms. Killey attended the 1990 annual meeting of the American Institute of Professional Geologists (AIPG) at Long Beach, CA, October 10-12, 1990, as the official delegate from the Illinois-Indiana Section. She also participated in the fall and spring meetings of the Illinois-Indiana Section of AIPG in Indianapolis, IN, November 16, 1990, and Louisville, KY, May 18, 1991. She attended two meetings of the North Central Section, Association of Engineering Geologists, held in Chicago on October 16, 1990 and March 19, 1991, and participated in a planning meeting for the 1991 AEG annual meeting held at St. Charles, IL, November 14, 1990.

**Dennis Kolata** spent 3 weeks in August 1990 collecting Ordovician volcanic ash samples in Estonia, Sweden and Norway with colleagues Warren Huff (University of Cincinnati) and Stig Bergstrom (Ohio State University). He also participated in a field trip on the Precambrian geology of the St. Francois Mountains of Missouri, led by Richard Hay of the University of Illinois, July 24-25, 1990; a field trip on the structural geology of the Shawnee Hills, southern Illinois, led by John Nelson (ISGS) and Stephen Marshak (University of Illinois), September 8, 1990; and the 20th annual field conference of the Great Lakes Section, Society of Sedimentary Geology (SEPM), entitled "Architectural elements and paleoecology of carbonate shoal and intershoal deposits in the Salem Limestone (Mississippian) in south-central Indiana," led by Todd Thompson and others, October 10-11, 1990. At a meeting of the Michigan Basin Geological Society in East Lansing, MI, November 14, 1990, Dr. Kolata presented the talk, "Tectonic history of the Illinois Basin."

**Robert Krumm** presented the talk, "Geologic mapping and modelling to support solid waste siting activities," at the Midwest/Great Lakes Section, ARC/INFO Users Conference, Kansas City, MO, September 20, 1990. He also participated in meetings of the Illinois (topographic) Mapping Advisory Committee at Springfield, February 15, 1991; the Indianapolis GIS Users Group, April 9, 1991; and the Illinois Chapter of the Soil and Water Conservation Society at DeKalb, June 27-28, 1991.

**Carl Kruse** participated in the Advanced research and technology development, direct utilization and instrumentation and diagnostics contractors' review meeting in Pittsburgh, PA, September 16-18, 1990, sponsored by the U.S. Department of Energy Pittsburgh Energy Technology Center. Dr. Kruse presented a talk, "Lignin-augmented bituminous coal depolymerization: a route to clean fuels," at the Engineering Research Foundation's Conference on fine coal cleaning, held at Palm Coast, Florida, December 2-7, 1990.

**Timothy Larson** participated in the semi-annual meeting of the Groundwater Committee of the Society of Exploration Geophysicists at Nashville, TN, March 10, 1991, and the Symposium on the Application

of Geophysics to Engineering and Environmental Problems, March 11-13, 1991, at Nashville. At that meeting, he was invited to join the steering committee for the 1992 symposium, which will be held in Oak Brook, IL, in April 1992.

**Morris Leighton,** with the assistance of **Suzanne Muckensturm** and design work by **Pam Foster** and the Publications, Graphics, and Photography Unit, developed an exhibit on behalf of the Association of American State Geologists. Its first showing was at the Geological Society of America in Dallas, TX, October 29–November 1, 1990.

**John Masters, John Nelson, and Joe Devera** of the ISGS, Richard Berg, visiting scientist from the Montana Bureau of Mines and Geology, and Mark Chatman of the U.S. Bureau of Mines, met in the field in southern Illinois, August 25-26, 1990, to review Dr. Berg's mapping and study of the microcrystalline silica (tripoli) deposits. Mr. Masters also met in the field with Don Chestnut and Gene Ameral of the Kentucky Geological Survey, and William Olive, USGS (retired), to review the geology of the Cretaceous-Tertiary rocks of the Mississippi Embayment. On June 14, 1991, Mr. Masters and **Leon Follmer** met with Steve Obermeier of the USGS to examine clastic dikes in the Quaternary, Tertiary, and Cretaceous rocks of southeastern and southern Illinois.

**Donald McKay** presented the slide-illustrated talk, "Computer-assisted geologic mapping for landfill siting in Champaign County, Illinois," for the Hydraulic Engineers luncheon meeting, October 18, 1990.

**Dennis McKenna** attended the Third National Research Conference on Pesticides, "Pesticides in the next decade: the challenges ahead," at Richmond, VA, November 8-9, 1990. He also participated in the Illinois Agricultural Pesticides Conference at Urbana, January 8-10, 1991. At the conference, "Research on agricultural chemicals in Illinois Groundwater: Status and future directions," sponsored by the Illinois Groundwater Consortium at Springfield, April 2, 1991, Mr. McKenna presented a talk, "Groundwater contributions to atrazine loadings in streams." **Edward Mehnert and Bruno Risatti** also participated in this conference.

**Melissa McLean** presented the poster exhibit, "Geologic Map of the Paducah CUSMAP Quadrangles," at an open poster session of the Midwest/Great Lakes ARC/INFO Users Conference, Kansas City, MO, September 19-21, 1990.

**Edward Mehnert** attended the conference, "Agriculture and food policy in an interdependent world — drinking water quality and agricultural chemicals," in Lisle, IL, February 14, 1991.

**Donald Mikulic** attended the joint meeting of the Northeastern and Southeastern sections of the Geological Society of America in Baltimore, MD, March 14-16, 1991. On May 10-12, 1991, he participated in the Michigan Basin Geological Society's field trip on the Lower Ordovician and Upper Cambrian of Wisconsin.

**Michael Miller** presented the talk, "Geomorphic and geohydrologic assessment for the management of constructed wetlands," at the annual meeting of the American Association of Geographers in Miami, FL, April 16, 1991.

**Donald Oltz** presented the talk, "The reservoir characterization program in Illinois," to the Kentucky Oil and Gas Association meeting in Owensboro, June 5, 1991. He also attended the meetings of the Illinois Oil Producers Association on September 20, 1990 and June 20, 1991; the Interstate Oil Compact Commission in Phoenix, AZ, December 1-5, 1990; and the annual meeting of the American Association of Petroleum Geologists in Dallas, TX, April 4-10, 1991. He also attended several of the monthly meetings of the Illinois Geological Society during the year.

**Matthew Riggs** attended the Indianapolis GIS Users Conference on April 9, 1991.

**Bruno Risatti** attended the annual meeting of the Geochemical Society at Dallas, TX, October 29-November 1, 1990.

**Michael Sargent** participated in the field trip on the structural geology of the Shawnee Hills led by John Nelson and Steven Marshak, September 7-9. The trip was planned for the annual meeting of the North

Central Section, Geological Society of America, but it was canceled due to lack of enrollment.

**Nicholas Schneider** was field trip leader and author of a major portion of the guidebook for the annual field conference of the Rocky Mountain Friends of the Pleistocene held in southwest Montana, August 15-19, 1990.

**Beverly Seyler** visited the Exxon Research and Development Company Laboratories and Offices in Houston, TX, February 21-23, 1991, to discuss her current research on sandstone reservoirs in the Illinois Basin.

**Wen-June Su** participated in the 4th International Geo/SQL Users' Conference held at Breckenridge, CO, April 10-14, 1991.

**Colin Treworgy** presented two talks at the Forum on Computing at State Geological Surveys, sponsored by the Kentucky Geological Survey at Lexington, KY, June 4, 1991: "Management and analysis of geologic data using a geographic information system" and "Designing a stratigraphic database: an example from the Illinois State Geological Survey."

**Janis Treworgy** presented the talk, "Tectonic subsidence history of the Illinois Basin," at the Louis Unfer, Jr., Conference on the Geology of the Mid-Mississippi Valley, Southeast Missouri State College, Cape Girardeau, MO. The conference included a field trip to outcrops in the Ozark Hills of Missouri. Dr. Treworgy also attended the annual meeting of the American Association of Petroleum Geologists, Dallas, TX, April 6-10, 1991, and, in conjunction with that meeting, the core workshop on mixed carbonate-siliciclastic sequences. During the fall, she participated in the field trip on the structural geology of the Shawnee Hills, led by John Nelson and Stephen Marshak, September 8, 1990. She and **Pius Weibel** also attended the 20th annual field conference of the Great Lakes Section of the Society of Sedimentary Geology (SEPM) in southern Indiana, October 10-11, 1990.

**Lectures/Classes/Seminars Taught**

**Robert Bauer** presented a seminar on the effects of longwall coal mining on aquifers and the ground surface for the Geology/Geophysics Seminar series at the University of Missouri at Rolla, March 8, 1991. He also presented a lecture on rock mechanics testing practices and applications to real world problems for the University of Illinois Geology Department.

**Dwain Berggren** gave a slide-illustrated talk, "The Geological History of Illinois," for a sub-freshman geography class at University High School, Urbana, October 2, 1990.

**Keros Cartwright** is serving as thesis advisor or a member of the advisory committee for 2 M.S. candidates at the University of Illinois and a Ph.D. candidate at Northern Illinois University.

**Chen-Lin Chou** presented a lecture, "Geochemistry and origin of sulfur in coal," for the Department of Chemistry, Western Kentucky University, Bowling Green, March 29, 1991. He is also a member of the M.S. thesis committee for a student at Western Kentucky University.

**Michael Chrzastowski** reviewed the coastal evolution of southern Lake Michigan for a class in Coastal Geomorphology at the University of Illinois on October 22, 1990, and summarized Illinois coastal geology for a General Geology class on April 5, 1991. He presented a summary of results from "Ongoing Lake Michigan Coastal Erosion Research" for the weekly graduate seminar at the Department of Geology, Northern Illinois University. Dr. Chrzastowski is providing informal advice to a graduate student at the University of Delaware who is continuing research he began while a student there.

**Joan Crockett** has assisted graduate students at Indiana University, Queens College (New York), and the University of Illinois in gathering samples and interpreting data.

**Heinz Damberger** is a dissertation advisor for a Ph.D. candidate at the Geology Department, University of Illinois.

**Gary Dreher** presented a lecture and demonstration on superconductivity at the Edison Middle School, Champaign, on February 6, 1991.

**James Eidel** coordinates aspects of the thesis research for two masters degree candidates at Western Illinois University.

**Leon Follmer** collaborated with Professor W. Hilton Johnson, University of Illinois, in presenting a graduate seminar on Quaternary Geology at the University of Illinois during the fall semester 1990. A two-day field trip to the lower Illinois River valley was included in the class. During the spring semester, Dr. Follmer lectured on the use of soils in geologic studies for the Southern Illinois University-Carbondale Geology Department, February 20, 1991. On March 6, 1991, he lectured a UI agronomy class on the concepts of time and paleosols in soil studies. At the University of Illinois, Dr. Follmer is helping to direct the research of 2 Ph.D. and 2 M.S. candidates in the Geology Department, 2 Ph.D. and 2 M.S. candidates in the Geography Department, and 1 Ph.D. and 2 M.S. candidates in the Department of Agronomy. He is also helping to direct the work of an M.S. candidate in the Geology Department, SIU-Carbondale, and Ph.D. candidates at Philipps University, Marburg, Germany, and the Laboratory of Loess and Quaternary Geology, Academia Sinica, Xian, China.

**Ardith Hansel** presented a lecture, "The late Wisconsinan record and deglaciation history in Illinois and the Lake Michigan Basin," for the Department of Quaternary Research of the University of Stockholm, Sweden, on October 9, 1990. At Rovaniemi, Finland, on October 13, 1990, Dr. Hansel presented a talk to staff members of the Geological Survey of Finland, "The Geology of Illinois and the role of the Illinois State Geological Survey." While in Finland, Dr. Hansel reviewed the doctoral dissertation of a geologist from the Finnish Geological Survey completing a Ph.D. at the University of Wisconsin-Madison. The study involved the use of remote sensing to characterize tills in Finland and Alaska. She also spent 4 days in the field with another geologist from the Finnish Survey who is studying the glacial deposits and glacial history of Finnish Lapland for a Ph.D. dissertation at the University of Turku in Finland. Back in the U.S., Dr. Hansel spent 2 days in the field with a student from Oregon State University who is beginning a research project using engineering data to model the Lake Michigan lobe of the Laurentide ice sheet as a means of testing the deformable bed model for the area.

**Richard Harvey** was demonstrator of a science project for the Children's Science Museum, December 16, 1990. He also judged science projects at the Urbana Middle School, March 7, 1991.

**Randall Hughes and Duane Moore** participate extensively in teaching graduate students and others in the techniques and uses of clay mineral analysis in solving geological problems. During the year they held working seminars for several students of Quaternary geology and professor Hilton Johnson of the University of Illinois and a representative of Marathon Oil Co. Dr. Hughes has provided extensive individual assistance to three graduate students at the University of Illinois and one from Queens College (NY).

**John Kempton** advised a geology graduate student from Northern Illinois University regarding the stratigraphy of the Paw Paw bedrock valley.

**Dennis Kolata** presented the lecture, "Tectonic history of the Illinois Basin," at the University of Missouri Geology Department, Columbia, MO, November 7, 1990. He is a member of the doctoral degree advisory committees of 3 students at the University of Illinois and one at Queens College (NY), and provides significant assistance regularly to graduate students at University of Wisconsin-Madison and Northern Illinois University.

**Robert Krumm** has provided technical assistance for a graduate student in geology at Northern Illinois University.

**Chao-Li (Jack) Liu** has assisted several graduate students in interpreting radiocarbon dates provided through our laboratory, and in the applications, techniques, and interpretation of isotopic analysis of groundwater samples.

**Morris Leighton** presented the lecture, "Interior Cratonic Basins," to the Department of Geology, University of Illinois on September 17, 1990.

**Donald McKay** is a member of the M.S. thesis advisory committee for a graduate student in the Department of Geography, UI-UC, working on computer representations of subsurface geology of glacial deposits.

**Donald Mikulic** led a field trip to the Thornton Quarry for science teachers on September 29, 1990. The trip was sponsored by the Chicago Academy of Sciences.

**Rodney Norby** is a member of Mr. Joe Devera's dissertation advisory committee at Southern Illinois University-Carbondale.

**Samuel Panno** lectured on the effects of gamma radiation on the chemistry of brine and rock salt and implications for disposal of nuclear waste in a salt repository for the Department of Nuclear Engineering, University of Illinois, on January 29, 1991.

**Philip Reed** provided technical assistance for four graduate students from Northern Illinois University during the year.

**Bruno Risatti** presented lectures on kinetic isotope effects in microbial systems for a microbiology class at the University of Illinois, December 1990, and the sources and significance of sedimentary biogenic methane at the Geology Department, Southern Illinois University-Carbondale, March 4, 1991. Dr. Risatti has provided technical assistance for two candidates for graduate degrees in Civil Engineering at Northwestern University, and a Ph.D. candidate in geology at Indiana University-Purdue University. He is a member of the graduate faculties of both Northwestern University and Purdue University.

**Massoud Rostam-Abadi** is a member of the dissertation advisory committees of 2 Ph.D. candidates for the Department of Civil Engineering, University of Illinois.

**William Roy** offered technical advice for a master's degree candidate in the Agronomy Department, University of Illinois.

**Nicholas Schneider** taught "Introduction to Physical Geology" at Parkland College during the year.

**Paul Terpstra** presented a one-hour lecture on erosion problems along the Lake Michigan shore and the development of a logarithmic spiral beach at North Point Marina for a class in Coastal Geomorphology at the University of Illinois, October 22, 1990.

**Pius Weibel** assisted Professor Ralph Langenheim and an undergraduate student from the University of Illinois in the field study and collecting of an Upper Pennsylvanian limestone. He also assisted in the teaching of the class, "Geology of the Grand Canyon," during the spring semester.

**Stephen Whitaker** discussed general geology and the geology of Illinois for 3rd grade and 5th grade classes at Robeson School, Champaign, on September 26, 1990 and May 15, 1991.

### Offices/Committee Memberships/Services for Professional Societies

**Robert Bauer** is Rock Mechanics Chairman for the North Central Section of the Association of Engineering Geologists. He is also a member of the Rock Mechanics and the Subsidence Committees of the national AEG and serves as official liaison between the two committees. For local chapters of other professional societies, Mr. Bauer presented a talk, "Earthquakes and their Effects in the Midwest," at the annual meeting of the Instrument Society of America in Decatur, IL, December 12, 1990. He gave the same talk for the American Institute of Plant Engineers meeting in Decatur, January 8, 1991.

**James Baxter** has served as a member of the Research Council of the Society of Mining, Metallurgy and Exploration (SME) since March 1990. He is also an Associate Editor and Member of the Editorial Committee for the sixth edition of *Industrial Minerals and Rocks* and a reviewer for contributions on industrial minerals to the journal *Mining Engineering*.

**Subhash Bhagwat** is a member of the Coal Utilization Committee of the Coal Division of the Society of Mining, Metallurgy and Exploration (SME).

**Ross Brower** is historian of the Midwest Groundwater Conference.

**Keros Cartwright** was Chairman of the Birdsall Distinguished Lecturer Committee for the Hydrogeology Division of the Geological Society of America until November 1990 and continues as Co-Chair of the Division's Ad Hoc Committee on Hydrostratigraphic Nomenclature. He served as President of the Illinois-Indiana Section of the American Institute of Professional Geologists until October 1990 and chaired the Section's annual meeting at Indianapolis, October 16, 1990. Dr. Cartwright continues to serve on the Editorial Board of the American Institute of Hydrology and on the Board of Practitioners for the McGraw-Hill Handbook of Hydrology.

**Chen-Lin Chou** is a member of the Finance Committee and chairs the Distinguished Service Award Committee for the Coal Geology Division of the Geological Society of America. He is also a participant in Project 254, "Metalliferous Black Shales," of the International Geological Correlation Project (IGCP).

**Michael Chrzastowski** is one of 56 members of the North American Working Group for the International Geological Correlation Program's Project 274 on Coastal Evolution in the Quaternary. For the American Society of Civil Engineers, Dr. Chrzastowski and Professor Charles H. Fletcher, III of the University of Hawaii organized and co-chaired the symposium, "Coastal Sedimentary Response to Sea Level Rise," honoring John C. Kraft at the international conference, COASTAL SEDIMENTS '91, in Seattle, WA, June 24-29, 1991. Mike and Peter Barnes of the U.S. Geological Survey organized and co-chaired a technical session, "Lake Levels and Coastal Stability: Geologic Implications and Historic Perspectives," for the 34th Conference on Great Lakes Research at Buffalo, NY, June 2-6, 1991.

**Joan Crockett** completed her term as president of the Illinois Geological Society (IGS) in September 1990. She continues to serve on the Board of Governors of the IGS and chairs the Society's Scholarship Committee. She is general co-chair for the Society's organizing committee arranging to host the 1992 annual meeting of the Eastern Section of the American Association of Petroleum Geologists. Ms. Crockett was the official delegate to the 1991 annual meeting of the American Association of Petroleum Geologists for the Illinois Geological Society. She is also a member of the Awards Committee of the Illinois Oil and Gas Association.

**Heinz Damberger** serves the Illinois Mining Institute as Secretary-Treasurer. In that capacity, he provides the general operating services that keep the IMI functioning smoothly. He also serves as co-chairman of the technical and entertainment program and edits the IMI Proceedings volume. The nine technical papers in the volume this year totaled 109 printed pages.

**Henry Ehrlinger III** is chairman of the Industrial Minerals Division of the Society of Mining, Metallurgy and Exploration (SME) for 1990-1991. In that capacity, he is also chair of the Executive Committee of the Division. During 1990, he was chairman of the Nominating Committee of the Division. He is also serving on the Scholarship Committee, the Hardinge Award Committee (through 1994) and the Young Scientists Award Committee. Until February 1993, he is serving on the Board of Directors of SME.

**James Eidel** is Vice President of the Society of Exploration Geologists Foundation. For the SEG, he also serves on the Committee on Committees, the Ad Hoc Committee on Geologic Mapping and the Thayer Lindsey Lecture Committee. He has been nominated for the office of President of the Society.

**Leon Follmer** is co-chairman of the Illinois Quaternary Association; president of the North American Loess Working Group of the Commission on Loess and secretary-treasurer of the Commission on Paleopedology of the International Union of Quaternary Research (INQUA). He has been appointed to

the North American Commission on Stratigraphic Nomenclature to revise the section of the Stratigraphic code on pedostratigraphy. Dr. Follmer serves on the editorial board of *Catena*, an international journal of soil science, hydrology, and geomorphology, and on the International Editorial Advisory Board of the Journal of Quaternary Science.

**David L. Gross** has begun a 3-year term on the committee on geology and public policy of the Geological Society of America.

**Ardith Hansel** is a Corresponding Committee Member of the Subglacial processes and sediments working group of the Commission on Formation and Properties of Glacial Deposits of the International Union of Quaternary Research (INQUA). In that capacity, she participated in the annual meeting and field trip held at Gmunden, Austria, September 16-21, 1990. She is also a Corresponding Committee Member of the INQUA Subcommission on North American Stratigraphy and Councilor for Historical Geology and Stratigraphy for the American Quaternary Association.

**Richard Harvey** chairs the Subcommittee on Coal Classification, Committee on Coal and Coke (D5) of the American Society for Testing and Materials. Until November 1990, he was publications editor for the Society for Organic Petrology (SOP). He is currently serving as Vice President of the SOP. Dr. Harvey has been a member of the Editorial Board of the Journal of Coal Quality since March 1990.

**Beverly Herzog** was elected to the Board of Directors of the Illinois Groundwater Association at the October, 1990 meeting. Until the fall of 1990, she served on the editorial board of the *Journal of Ground Water* and she is currently serving on the editorial board of *Ground Water Monitoring Review.* Ms. Herzog is a member of the subcommittee on soil and water of Committee D-18 of the American Society for Testing and Materials.

**Richard Howard** is a member of the Geological Committee of the Illinois Oil and Gas Association.

**Bryan Huff** compiles data on various aspects of oil and gas exploration and production for numerous reports. Among them are the data for the Illinois Oil and Gas Association's "Wildcatter of the Year" award; the American Association of Petroleum Geologists 3-, 6-, and 10-year exploratory well reserves estimate, the annual stripper well report for the Interstate Oil and Gas Compact Commission/National Stripper Well Association survey, and the annual state agency survey for *World Oil* magazine.

**Randall Hughes** served as a Councilor for the Clay Minerals Society from 1988-1990 and continues to serve on the Nominations and Policy Committees of that organization. For the Society of Mining, Metallurgy and Exploration (SME), he chairs the Editorial Committee of the Industrial Minerals Division for articles submitted to the society's journal *Mining Engineering.* He is also a member of the *Mining Engineering* and technical committees of SME. Dr. Hughes is a candidate for managing editor for North and South America for the *Journal of Applied Clay Science.*

**John Kempton** was co-editor of Geological Society of America (GSA) Special Paper 258, *Geology and hydrogeology of the Mahomet-Teays bedrock valley system.* The volume was published shortly after the beginning of FY 1992. The executive director of the GSA also appointed Dr. Kempton to a 3-year term as GSA representative on the Committee on the John C. Frye Memorial Award.

**Latif Khan** is a member of the technical papers subcommittee of the Society of Mining, Metallurgy and Exploration (SME).

**Myrna Killey** is serving as Field Trip Coordinator for the 1991 annual meeting of the Association of Engineering Geologists to be hosted by the North Central Section in the Chicago area in early FY 1992. For the Illinois-Indiana Section of the American Institute of Professional Geologists (AIPG), Ms. Killey is currently a member of the Executive Committee and newsletter editor. She has been nominated for the office of Secretary of the national AIPG.

**Dennis R. Kolata** was president of the Great Lakes Section, Society of Sedimentary Geology (SEPM) until October, 1990. In that capacity, he organized the SEPM symposium held at the annual meeting of

the North Central Section, Geological Society of America and chaired a session on tectonics at that meeting.

**Morris Leighton** served as Vice President of the Association of American State Geologists (AASG) and was elected President-Elect at the Association's spring 1990 meeting in Saratoga, New York. He also serves on the AASG Liaison Committee, which meets twice annually in Washington, D.C. to review federal/state programs and issues with various federal agencies, institutions, and congressional staff.

**Duane Moore** is a member of the Council and chair of the Publicity Committee of the Clay Minerals Society.

**Donald Oltz** is serving on the Research and the Membership Committees of the American Association of Petroleum Geologists. He has been appointed chairman of the Technical Program Committee for the annual meeting of the Eastern Section of AAPG to be held in Champaign in September 1992.

**Russell Peppers** is a member of the Midcontinent Pennsylvanian Working Group for the Society of Sedimentary Geology (SEPM). Dr. Peppers also is a member of the working groups on the Pennsylvanian and the Middle Pennsylvanian of the Subcommission on Carboniferous Stratigraphy, International Union of Geophysical Societies.

**Bruno Risatti** is a member of the Organizing Advisory Committee of the International Conference on Processing Utilization of High Sulfur Coals.

**Michael Sargent** is institutional membership representative for the Geological Society of America.

**Beverly Seyler and Stephen Whitaker** were official delegates to the annual meeting of the American Association of Petroleum Geologists annual meeting in Dallas, TX, April 6-10, 1991. Ms. Seyler also is a member of the organizing committee for the annual meeting of the Eastern Section, AAPG, to be held in Champaign in September 1992.

**Wen-June Su** is Newsletter Editor for the North Central Section of the Association of Engineering Geologists.

**Pius Weibel** is Vice President of the Great Lakes Section of Society of Sedimentary Geology (SEPM) and a member of the Midcontinent Pennsylvanian Working Group of the SEPM. He participated in the spring business meeting of the section at the North Central GSA meeting in Toledo, OH, April 18-19, 1991. Dr. Weibel is the principal organizer of the fall field conference of the Great Lakes Section of SEPM.

**Stephen Whitaker** presented a talk on reservoir heterogeneity in the Bartelso Field at a monthly meeting of the Illinois Geological Society, February 26, 1991.

## CONTRIBUTIONS TO OTHER GOVERNMENT AGENCIES

### Testimony/Information Supplied to Local/State/National Agencies/Committees

**Curtis Abert, Robert Krumm, Donald McKay, Lisa McLean, Matthew Riggs** and other staff of the Geologic Mapping and Digital Cartography Section met with county officials on several occasions during the year to discuss services available or review progress on existing projects. They met with the Staff Technical Committee of the McLean County Board on April 4, 1991, and made slide presentations to the McLean County Board at a public meeting on April 29, 1991. Our presentations highlighted the mapping and other services provided by the ISGS to the Champaign County Intergovernmental Solid Waste Disposal Association as an example of the kinds of services available. Representatives from the ENR Offices of Solid Waste Reduction and Recycling and Research and Planning also made

presentations at this meeting. Other presentations during the year included those to the Kankakee County Regional Planning Commission (Kankakee, December 17, 1990), the Lake County Planning staff (Waukegan, March 1, 1991), and representatives from the Will County Land Use department (Springfield, March 26, 1991).

**Richard Berg and Brandon Curry** participated in document concurrence meetings for reports prepared for the low-level waste disposal site characterization program. Meetings on the site geology reports were held July 9-10, 1990, and meetings of site hydrology were held on November 8-9 and December 13-14, 1990. Brandon Curry also participated in several informal meetings with Battelle Memorial Institute staff at Martinsville and Springfield, and one meeting with Battelle and other contractors at Seattle, WA.

**Subhash Bhagwat** provided a written deposition to the Boone County Board on aggregate resources, markets, production, and prices in northern Illinois. The information was considered during hearings on the proposed expansion of the Irene Quarry of Rockford Blacktop Company. He also provided information on economic evaluations of the ethanol-coal desulfurization project to representatives of the executive and legislative branches at meetings in Washington, DC, July 24-25, 1990, arranged by the Illinois Corn Marketing Board.

**Michael Chrzastowski** provided technical information for officials of the City of Lake Forest and representatives of the U.S. Army Corps of Engineers and the Division of Water Resources of the Illinois Department of Transportation at a meeting held January 29, 1991. He and **Paul Terpstra** met with officials of the Department of Conservation and the Illinois Capital Development Board on March 28, 1991, to discuss the design and life expectancy of planned interim shore defense structures at the North Point Marina. On October 9, 1990, Dr. Chrzastowski provided technical data on erosion problems along the southern part of Illinois Beach State Park for a proposal on coastal sand management being prepared by the Chicago District, U.S. Army Corps of Engineers. He also responded to a survey questionnaire from the Marine Board of the National Research Council on marine habitat management along the Illinois lakeshore.

**James Eidel** participated in meetings with representatives of the U.S. Geological Survey and other state geological surveys in St. Louis, MO on February 1 and March 5, 1991, to plan an upcoming workshop on industrial minerals. During the year, he also provided information orally and in writing on the potential mineral resources in the Shawnee National Forest. Among the presentations were a lengthy conference call with Regional Forester Butch Marita on January 22, 1991, and a White Paper on the possible use of CUSMAP information in educating the public about potential mineral values in the Shawnee. The White Paper was presented by representatives of Ozark-Mahoning Fluorspar Mining Company at a U.S. Forest Service-Industry workshop on mineral resource related problems in national forests in the eastern region. Mr. Eidel and other appropriate ISGS staff were unable to attend the workshop because it conflicted with the in-house workshop on the Paducah CUSMAP.

**David Gross** participated in a meeting of the National Governors Association Working Group on Science and Technology in Washington, DC, in April 1991.

**Keith Hackley** participated in the deposition hearings on the final preparation of the geochemistry chapter for Battelle's report to the Illinois Department of Nuclear Safety on the Martinsville Alternative Site for the Low-Level Waste repository.

**Ardith Hansel, Michael Miller, and John Kempton** provided information about the Quaternary geology of the Lake Calumet area for use by the Water Survey in undertaking a study of the hydrology of the area.

**Richard Harvey** chaired a Program Review Panel for the U.S. Department of Energy, December 10-13, 1990.

**Randall Hughes**, through his membership in Volunteers in Service to America (VISTA), provided advice to the U.S. State Department on low-technology solutions to industrial minerals production and manufacturing problems in developing countries.

**James Jennings** prepared digital versions of Lake Michigan shoreline erosion maps for the Chicago District, U.S. Army Corps of Engineers. He also provided information on shoreline erosion near the Indiana state line for the Chicago Park District. He also participated in a meeting regarding Lake Michigan shoreline management with representatives of the Illinois Department of Conservation and Corps of Engineers in August 1990.

**Donald Keefer** presented the talk, "Groundwater protection mapping at the Illinois State Geological Survey," for the Illinois (topographic) Mapping Advisory Committee, February 15, 1991 at Springfield, IL.

**John Kempton** presented a talk, "Understanding the Quaternary framework of Illinois: a necessity for a 'surficial' mapping program," at the fall meeting of the Illinois Geologic Mapping Advisory Committee at Starved Rock State Park Lodge, November 1990.

**Myrna Killey** prepared a report on the geologic framework of Red Hills State Park, Lawrence County, IL for the Illinois Department of Conservation. She also prepared a report for McHenry County officials on the possible impact of the Possum Run Pit of Meyer Materials Company on the water level in Lily Lake.

**Robert Krumm** prepared several files of digital map information for county and local government agencies. Among them were printed listings of State Plane Coordinates for all section corners in Macon County for the City of Decatur, and for the section corners in Edgar and Vermilion Counties for their county governments. The soils information for Champaign County compiled for the Champaign County landfill screening project is being transferred to Digital Line Graph format and delivered to the Soil Conservation Service under an interagency agreement.

**Hannes Leetaru** presented portions of the paper, "An integrated approach to reservoir characterization in the Illinois Basin," to the Petroleum Advisory Committee/Technical Advisory Committee meeting in Mt. Vernon, IL, December 13, 1990. Mr. Leetaru also presented a synopsis of his King Field study, reviewed some preliminary results from his study of the Boyd Field, and discussed aspects of seismic modeling of the Aux Vases and Cypress sandstones (Mississippian). Others who attended and made presentations at the meetings included **Scott Beaty, John Grube, Morris Leighton, Kenneth McGee, Donald Oltz, Richard Rice, Beverly Seyler, Stephen Whitaker, and John Yeko.**

**Morris Leighton** presented testimony on May 23, 1990 to the Illinois Senate in Springfield on Geologic Mapping in Illinois.

**John Masters** participated in a meeting on aggregate source certification held at the Illinois Department of Transportation's Bureau of Materials and Physical Testing in Springfield, May 14, 1991.

**Donald McKay** participated in a public hearing on the Lands Unsuitable for Mining report on Salem Township, Knox County, held August 14, 1990 at Carl Sandburg College, Galesburg. He also met in Urbana on November 7, 1990 with representatives of the U.S. Geological Survey Water Resources Division, Illinois District Office, to coordinate drift thickness, bedrock topography and aquifer mapping programs. On March 1, 1991, representatives of the U.S. Army Corps of Engineers, St. Louis District, came to Champaign to assess the utility of GIS for projects in the Rend Lake area in southern Illinois.

**Dennis McKenna** presented the talk, "Groundwater contributions to atrazine loadings in streams," to the Champaign County Soil and Water Conservation District Technical Committee for the Embarras River Basin Study, May 15, 1991.

**Donald Mikulic** met in 1990 with a representative of the National Park Service on September 28 and December 5 and led field trips on December 7, 10, and 11 to sites in Illinois considered to be significant in the history of the science of geology. The Park Service is considering developing a national inventory of such sites.

**Michael Miller** prepared written information expressing the views of the ISGS on the effects of the No-Net-Loss criterion for wetlands protection for use in ENR's agency comments on a report prepared by the Domestic Policies Council. Dr. Miller also provided information on wetlands to the Instream Flow Committee that was included in the Committee's final report to the General Assembly. At the request of the U.S. Army Corps of Engineers, Dr. Miller reviewed four applications for possible wetland disturbance under the "404" permit requirements.

**Walter Morse** prepared a report, "Geology and geologic resources of the Bear Creek River Basin and vicinity, Adams and Hancock Counties, Illinois," for the Bear Creek River Basin Resource Planning Committee.

**Donald Oltz** and other members of the Oil and Gas Section staff reviewed and commented on proposed legislation affecting regulation of the oil and gas industry and the lodgement of oil and gas records at the ISGS. Dr. Oltz attended a meeting of the Oil and Gas Board of the Department of Mines and Minerals on April 12, 1991, and provided technical advice on regulations on spacing of oil wells in the light of findings on reservoir heterogeneity and the need for infill drilling for improved and enhanced oil production from known reservoirs.

**Philip Reed** met with public officials to review the geologic history of the local area and discuss the scope and geophysical methods used by the ISGS in exploring for groundwater, and to answer any questions prior to performing an electrical earth resistivity survey for a municipality or municipal water supply district. He also provided handouts on the geophysical techniques, the State Geological Survey's research and service programs, and the Educational Extension Field Trips. Fifty-five such meetings were held during the reporting period.

**Nicholas Schnelder** participated in the bi-monthly meetings of the Kane County Water Association to keep the membership informed about progress on the work being done by the ISGS on the county's shallow groundwater resources.

**Wen-June Su** presented a talk, "Landslides in the New Madrid Seismic Zone," at the meeting of the Illinois (topographic) Mapping Advisory Committee on February 15, 1991, at Springfield.

### Participation on Local/State/National Government Advisory Committees

**Robert Bauer and David Gross** are members of the MagLev Advisory Board for Argonne National Laboratory.

**James Baxter** participated in the first and second planning meetings for the USGS-sponsored workshop on Industrial Minerals to be held in St. Louis in early FY 1992. Dr. Baxter also reviewed a draft environmental impact statement for the Shawnee National Forest for the U.S. Forest Service, responded to a U.S. Forest Service questionnaire on the effectiveness of a mediation process used to attempt to resolve differences between the Forest Service and concerned citizens regarding the draft 10-year forest plan for the Shawnee National Forest, and provided information and maps about mined-out areas in Hardin and Jo Daviess Counties for Senator Dixon's staff.

**Richard Berg** represents the ISGS on the Interagency Coordinating Committee on Groundwater. He also serves on an advisory committee to USEPA Region V for midcontinent contamination potential mapping.

**Dwaln Berggren** was appointed to a 3-year term on the Citizens Advisory Committee of the Champaign County Forest Preserve District Board. His term will end in June 1994.

**Subhash Bhagwat** reviewed the results of his study of the benefits and costs of geologic mapping for the Illinois Geologic Mapping Advisory Committee at Starved Rock State Park Lodge, November 15, 1990, and for the Illinois Board of Natural Resources and Conservation at Eagle Creek, May 3, 1991.

**Richard Cahill** compiled and sent information on indoor radon and the role of the ISGS in studies of the indoor radon problem to Randy Schumann, U.S. Geological Survey, Midwest coordinator of the joint USEPA/USGS/Association of American State Geologists cooperative project on the relationship of geology to the occurrence of high levels of indoor radon. He also supplied information on the occurrence of radon in water in Cook County to the Illinois Department of Public Health. For the Illinois EPA, he supplied information on the levels and sources of nickel in sediments in the Upper Illinois River waterway. Mr. Cahill presented written material and an informational seminar for the Environmental Advisory Committee of the Champaign City Council, "Yard waste composting—What are the issues for the city government." He serves as ISGS facility coordinator for the Illinois Emergency Management Agency (formerly IESDA) as required under the Superfund Amendment and Reauthorization Act.

**Keros Cartwright** is a member of the Technical Advisory Committee on Low-Level Radioactive Waste Disposal Siting for the State of North Carolina. He also serves on the Environmental Advisory Committee for the Savannah River Site for the U.S. Department of Energy and Westinghouse Savannah River Company and is a member of the Science Advisory Committee of the U.S. Environmental Protection Agency.

**Heinz Damberger** organized the programs for the fourth and fifth semi-annual meetings of the Illinois Geologic Mapping Advisory Committee held at Starved Rock State Park Lodge in November 1990 and in Springfield in May 1991. Dr. Damberger also organized the program for the annual meeting of the ISGS Coal Advisory Committee held at the Illini Union in May 1991. He serves as a member of the Steering Committee of the U.S. Department of Energy/Energy Information Agency Coal Reserve Assessment program. He is also a member of the National Research Council's Ad Hoc Committee on Mineral (Coal) Availability.

**James Eidel** participated in the deliberations of the Illinois Geologic Mapping Advisory Committee at Starved Rock State Park Lodge in November 1990 and at Springfield in May 1991. Other staff members who made presentations or participated in one or more of the meetings included **Jonathan Goodwin, Michael Chrzastowski, and John Kempton**.

**Leon Follmer** is a member of the University of Illinois Committee on Reclamation of Mined Land and Mine Refuse.

**Jonathan Goodwin** represented the ISGS at the 1990 Central Region Cluster meeting with representatives of the Geologic Division of the U.S. Geological Survey. The meeting was held in Baton Rouge, LA, September 8-11, 1991.

**David Gross** served for a second year as the Executive Director of the Governor's Science Advisory Committee (GSAC) while on leave from the ISGS. In that role, he organized and staffed three meetings of the GSAC and two meetings of the GSAC Executive Committee and provided staff support for meetings of the Illinois Coalition, Inc. He also made presentations to the bidders conferences of the Illinois Department of Commerce and Community Affairs Technology Challenge Grant program and, with the staff of the Illinois Coalition, made site visits throughout the state to 60 projects funded by the Challenge Grant program. Gross and the staff of the Illinois Coalition organized and provided staff support for the ten review panels that considered the 234 applications and recommended the projects to be funded from the $17.2 million Technology Challenge Grant program from FY 1992. Dr. Gross serves as Vice-Chairman of the Math Science Advisory Committee of the Illinois State Board of Education and was a member of the planning committee for the conference on the Clean Air Act Amendments organized and hosted by the University of Illinois at Chicago.

**Ardith Hansel** is a member of the technical review panel for the Great Lakes Protection Fund.

**Beverly Herzog** represents the ISGS on the Instream Flow Protection Committee of the State Water Plan Task Force. The committee delivered a major report to the Governor and the General Assembly in April 1991. Ms. Herzog also participated in a meeting of the State Water Plan Task Force in February 1991 where she offered comments on a report to the General Assembly on the accomplishments and directions of the Task Force. Beverly is a technical advisor for the Sheffield Citizen's Advisory Committee

on the decommissioning of the low-level radioactive waste disposal site there. Ms. Herzog and **Sam Panno** represent the ISGS on the State's Groundwater Monitoring Well Construction Committee and, in that capacity, reviewed sets of proposed standards for construction of such wells.

**Richard Howard** is a member of the Potential Gas Committee of the Potential Gas Agency. He also represents the ISGS on the Enhanced Recovery Committee of the Interstate Oil Compact Commission.

**Bryan Huff** provided annual updates on the lists of active oil and gas operators in Illinois and oil and gas field master codes and information on the annual quantity and value of natural gas for the Energy Information Agency of the U.S. Department of Energy.

**Russell Jacobson and Plus Welbel** represent the ISGS on the Tri-State Committee on Correlations in the Pennsylvanian System of the Illinois Basin.

**Timothy Larson** participated in the annual meeting of the Central United States Earthquake Consortium (CUSEC) at Indianapolis, December 7, 1990.

**Morris Leighton** served as Secretary of the Illinois Geologic Mapping Advisory Committee, presenting to that group the status of the geologic mapping report requested under a Senate resolution and of the Survey's geologic mapping initiative at the November 1990 and the May 1991 Advisory Committee meetings. He also serves as Secretary of the Coal Advisory Committee to the Illinois State Geologic Survey. That Committee held its annual meeting in May 1991. During the calendar year 1991, Morris Leighton also served as Chair of the Department of Energy and Natural Resources' Geographic Information System (GIS) Policy Committee. He continues to serve on the Petroleum Advisory Committee, which provides guidance to the State of Illinois/Department of Energy Project, "Research on Improved and Enhanced Oil Recovery in Illinois through Reservoir Characterization."

**Dennis McKenna** is a member of the Pesticide Subcommittee of the Interagency Coordinating Committee on Groundwater. He chairs the working group on aquifer vulnerability mapping and is a member of the working group on groundwater monitoring. He participated in meetings of these groups on July 16, September 25, and November 20, 1990.

**Michael Miller** is a member of the Wetlands Advisory Committee of the Illinois Department of Conservation.

**Donald Oltz** is a member of the Reservoir Classification Technical Subcommittee of the Energy Resources Committee of the Interstate Oil Compact Commission and a member of the Technical Energy Production Research Committee of the National Institute for Petroleum and Energy Research (NIPER).

**Samuel Panno** is a technical advisor to the Southwestern Illinois Planning Commission and the Mississippi Karst Resource Planning Committee. He is currently preparing maps on the karstic areas of Monroe, St. Clair, and Randolph Counties for the committee.

**Bruno Risatti** is a member of the Waukegan RAP Technical Advisory Committee for the Illinois EPA and a member of the Chicago Environment Group.

**Nicholas Schneider and Robert Bauer** are members of the Illinois Department of Transportation Hazardous Waste Committee.

## CONTRIBUTIONS TO THE PUBLIC AND INDUSTRY

### Popularized Addresses/Presentations for Civic Groups/Public Meetings

**Robert Bauer** presented a talk on Earthquakes and their effects in the Midwest to the American Red Cross Chapter in Urbana, IL, September 24, 1990. He also discussed the same topic for the management team of the Galatia Mine on November 20 and for a total of 500 miners in four sessions at the Galatia Mine, November 28-29, 1990. On May 9, 1991, at the Elkhart Mine of Turris Coal

Company, Mr. Bauer discussed the results of research related to room and pillar mines of the Illinois Mine Subsidence Research Program for members of the Board of the Nature of Illinois Foundation.

**Dwain Berggren** presented the slide-illustrated talk, "Illinois Geology and the Illinois Geological Survey," to the Rossville Historical Society, August 28, 1990.

**Michael Chrzastowski** discussed Holocene evolution of the Illinois lakeshore and 1989 discovery of 8,300-year-old forest remains on the lake floor in the first of a series of seminars on the history and evolution of Lake Michigan held at the Chicago Academy of Sciences, November 6, 1990. The discovery of the forest remains, interpretations of subsequent findings about the site, and talks about these and other findings on coastal erosion of southern Lake Michigan presented by Dr. Chrzastowski continued to provide substantial press coverage for the ISGS during the year, including items in *Geotimes* and *Earth Science*, national magazines published by the American Geological Institute.

**Leon Follmer** presented the illustrated lecture, "Loess, dust and the climate that shapes the land of Illinois," for the Men's Club of Athens, IL, October 16, 1990. He also was the banquet speaker for the Annual Soil Conservation Service Workshop, March 5, 1991. He reviewed his studies of soils in Argentina and Brazil.

**David Gross**, as executive director of the Governor's Science Advisory Committee, spoke on about two dozen occasions to discuss the importance of science and technology to the economy of the State. Among others, he spoke to the Association of University Officers for Sponsored Research Programs in Chicago and the City of Chicago Economic Development Department in July 1990, the East Central Community College in Mt. Carmel in May 1991, and the Executive Council of the Institute for Illinois in Chicago in June 1991. He also spoke at the dedication of the Illinois Institute of Technology West Campus in December 1990. In November 1990, he attended the Annual meeting of the Illinois County Officials Association in Chicago.

**Ardith Hansel** presented hands-on workshops on working as a glacial geologist for 7th, 8th, and 9th grade girls at the conference, "Expanding your horizons in math and science," held at Sangamon State University in Springfield, April 13, 1991. **Brenda Mehnert** presented the poster exhibit, "Every Day is Earth Day at the ISGS," at this conference. **Beverly Herzog** presented this poster exhibit at a similar conference for 6th - 10th grade girls at Illinois State University in Bloomington, March 16, 1991. Dr. Hansel was a panelist for a conference for 11th and 12th grade young women entitled "Science careers in search of women" at Argonne National Laboratory, May 3, 1991. **Myrna Killey** presented one of four keynote talks and participated in discussion sessions on various aspects of science careers at the conference, "Celebrating Earlham Women in Science," held at Earlham College, Richmond, IN, April 13. On the preceding day, she discussed the job market and some of her current projects at the ISGS with Earlham College geology department students and faculty.

**Bruce Hensel** presented a slide-illustrated talk on groundwater flow at the Des Plaines River Wetlands Demonstration project at a meeting sponsored by Wetlands Research, Inc., Lake County, November 1990.

**Russell Jacobson** led a fossil-collecting field trip to southern Illinois, October 21-22, 1990, for the Urbana Park District. About 15-20 people participated in this annual event.

**Jay Kelleher** gave a talk, "Safety, preparing oneself for an earthquake," on November 8, 1990 to staff at the southwest plant, Urbana-Champaign Sanitary District.

**John Kempton** provided references and copies of reports and had three telephone conversations with reporters from the Huntington, WV public television station regarding the relationship of the Teays bedrock valley to the origin of the Ohio River.

**Myrna Killey** presented a talk, "Landslide hazards of Illinois," for a conference on disaster preparedness sponsored by the University of Illinois-Chicago in observance of World Health Day, April 17, 1991.

**Robert Krumm** met with reporters from the Bloomington *Pantagraph* and radio station WJBC on April 29, 1991, to provide additional information following his presentation on landfill siting to the McLean County Board.

**Dennis McKenna, Edward Smith,** and Warren Goetsch of the Illinois Department of Agriculture, were interviewed over "Telenet," the radio service of the Cooperative Extension Service on August 7, 1990, regarding rural water supplies and water wells.

**Suzanne Muckensturm and Nicholas Schneider** presented exhibits about ISGS research and service programs at semi-annual meetings of the Illinois Association of County Board Members and County Commissioners in Chicago and Springfield. On August 11, 1990 in Springfield, Mr. Schneider presented the talk, "Resource identification, environmental management and economic development," twice. He also gave this talk to the sunrise Rotary club in Champaign

**Donald Oltz** was interviewed by reporters from the *Chicago Tribune* and WCIA-TV in Champaign with regard to Middle East oil resources on September 6, 1990.

**Bruno Risatti** presented a slide-illustrated talk on the chemistry and microbiology of Volo Bog for the Friends of Volo Bog at the Nature Center, Volo, IL, February 21, 1991.

**Massoud Rostam-Abadi** provided information about the high-surface-area hydrated lime for articles that appeared in the *Chicago Tribune* on Sunday, November 25 1990, the London *Financial Times*, February 6, 1991, and the May 1991 issue of *Power Magazine*. Dr. Rostam-Abadi and **David Moran** worked extensively with representatives of Research Corporation Technologies (RCT) in developing marketing materials for the process. Materials on combustion research at the ISGS were used by the ENR Office of Coal Development and Marketing for their publication, *Illinois Coal*.

**Stephen Whitaker** presented a slide-illustrated lecture on the future of the oil industry in Illinois for the Desk and Derrick Club in Fairfield, IL, January 16, 1991. He was presented with a certificate of appreciation for his talk.

**Other Services to the Public**

**James Baxter** provided information on fluorspar mining to a reporter from the *Chicago Tribune*.

**Richard Berg** is a member of the *Advisory and Evaluation Committee for Groundwater Protection* for Business and Professional People in the Public Interest (BPI), a public interest group in Chicago.

**Kristi Brewer, Larry Wu, Dan Adomaitis, and Gwen Donnals** presented an exhibit on the Ethanol Coal Desulfurization Project at the Illinois State Fair, Springfield, August 9-19, 1990, at the request of the Illinois Corn Marketing Board, one of the project sponsors. They also participated in parts of an interview with project Principal Investigator Larry Wu by WCIA-TV, Champaign, on April 5, 1991.

**Richard Cahill** was a judge for the science fair at Holy Cross School, Champaign, February 19, 1991.

**Phil DeMaris, Myrna Killey, and Edward Smith** served as judges for the regional science fair of the Illinois Junior Academy of Science held at Parkland College in Champaign, March 16, 1991. Mr. DeMaris provided information on aspects of the geology of coal mining in Illinois for reporters from the Charleston *Times-Courier* and the Bloomington *Pantagraph*.

**Gary Dreher** served as unit leader for the campus charitable fund drive for the ISGS and **David Gross** is a member of the University of Illinois Campus Charitable Fund Drive Committee.

**John Masters** is judging chairman for the Earth Science Division of the Illinois Junior Academy of Science. He and **Philip Reed** supervised the earth science division judging at the annual exposition at the Assembly Hall, May 18, 1991. Others who served as judges included **Myrna Killey and Edward Smith.**

**Richard Rice** was a judge at the science fair at the Dr. Howard School in Champaign, March 21, 1991.

**Robert Valden** helped the Urbana Park District plan and run "Dinosaur Days," an event for school children. He was available at the event to talk about geology (and dinosaurs) with the kids.

For the Engineering Open House on the University of Illinois campus, March 1-2, 1991, the Illinois Mine Subsidence Research Program presented an exhibit to highlight their activities. **Billy Trent, Dan van Roosendaal** and several other staff members of the IMSRP greeted visitors and discussed the research project during the 2-day show.